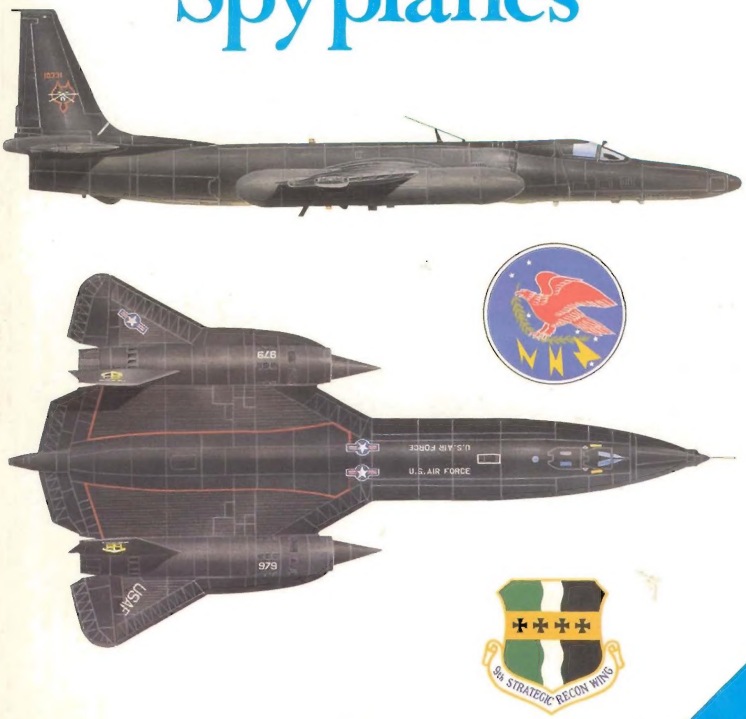
American Spyplanes



MIKE SPICK

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COMBAT AIRCRAFT SERIES

American Spyplanes

MIKE SPICK

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The Author

MIKE SPICK has had a lifelong interest in military aviation, and is author of several technical books and articles in aviation magazines covering various aspects of the subject. One of his leisure pursuits, wargaming, led him to a close study of air warfare, combat aircraft and the evolution of air combat tactics, on all of which he has written extensively.

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Introduction

Reconnaissance was the earliest function of the military aeroplane, which proved its value in this role as early as 1914. Its worth in wartime is obvious, specifically that of giving commanders on the ground a picture of what the enemy is doing and, indeed, where he is doing it. It has also been widely used in peacetime as a means of keeping abreast of developments in a potentially hostile country or even a friendly one if it is felt that details of certain technical developments might be of use. By the late 1930s this practice had become quite widespread, classic examples being the propensity of Lufthansa airliners to stray over the RAF fighter airfield at Biggin Hill, Sidney Cotton's epic flights over Germany in his camera-laden Lockheed 12A in the final two months before World War 2 and, very relevant to the present day, German airship flights made up the East coast of England to monitor radio frequencies and emissions.

Cold war mistrust

With the outbreak of World War 2, the gathering of intelligence by aircraft became an overt activity rather than a covert one and was brought to a high degree of effectiveness. The cessation of hostilities brought with it a relaxation of effort, but the intransigent attitude of the Soviet Union—intransigence which brought about what is known as the Cold War—ensured that reconnaissance missions did not entirely cease. The ensuing atmosphere of international mistrust saw to that, incidents such as the shooting down of a British European Airways Viking airliner over Berlin by Russian fighters in April 1948 doing little to help.

The so-called Iron Curtain then slammed down, effectively cutting the world into two camps. At the time, the West was fortunate in having nuclear weapons and the means to deliver then. The Soviet Union had neither, but it was only a matter of time before they developed them. The United States regarded intelligence on this and other matters as vital and reconnaissance aircraft performed covert intelligence gathering missions to this end.

This is where the expression "Spyplanes" originates for, while reconnaissance in wartime is an essential and honourable function, reconnaissance in peacetime is no less essential, but the means have to be concealed. The term "Spyplanes" is anathema to the USAF and has been known to make a very distinguished Colonel choke on a good malt whisky. Nevertheless, it does fully describe the mission.

Types of sensor

Aircraft have many ways of gathering information. For instance, they can use optical or infra-red photography. They can employ radar to scan the area over which they are passing. They can monitor the various radio frequency emissions, either radar or communications. They can take air samples for signs of radioactivity in areas where nuclear tests have been conducted. When interpreted and collated, the information gathered by these disparate means can be built up into a broad or, sometimes, very detailed picture.

There are two main methods of aerial intelligence gathering. One is to fly a stand-off route, staying in friendly or international airspace while peering over the border with whatever means are available. This has the disadvantage that only a relatively small area can be covered, which, in the case of a vast country like the USSR, leaves the hinterland untouched. The other method is to overfly the area to be reconnoitred. This naturally entails a measure of risk and the art of successful overflight is not to get caught.

Overflight is much more satisfactory for many reasons. Firstly, subject only to the proviso that the reconnaissance aircraft has enough range, any desired area can be examined. Secondly, any particular-

ly interesting features can be noted for more intensive scrutiny at a later date. Thirdly, it provides a test of the effectiveness of the defences. Finally, if the mission to be flown is electronic intelligence (Elint) gathering on the deployment and capability of defensive radar systems, it should induce them to switch on in order to track the intruder and their emissions can then be monitored and recorded. They are hardly likely to foil this by staying off the air, as they will not know the purpose of the mission, and will want to track the intruder in order to establish what areas it is interested in.

Advantages of altitude

Overflight is best carried out at high altitude. This gives a much longer reach to both photographic and radar equipment, permitting it to cover a greater area. On the other hand, it has the disadvantage of making the reconnaissance aircraft much more vulnerable to detection by radar, and detection will almost inevitably be followed up by an attempt at interception. The intruder must therefore have the capability to evade interception.

Lockheed's two high fliers

The United States has produced a number of aircraft aircraft over the years with just such a capability and two of these form the subject matter of this volume. First, there was the U-2, with a high altitude capability that, for a few years, put it well beyond the reach of Soviet defences. Then came the A-12 and SR-71 family, which combined superior high altitude capability with unsurpassed sustained cruising speed. While stand-off reconnaissance aircraft of the USAF and USN have done, and continue to do, a first class job of intelligence gathering, this is essentially the story of Lockheed's two high fliers.

Below: The widely disparate performance of Lockheed's high-flyers means that they have only rarely occupied the same area of sky at the same time. This specially posed publicity picture features Lockheed's test SR-71A and a much-modified U-2R.

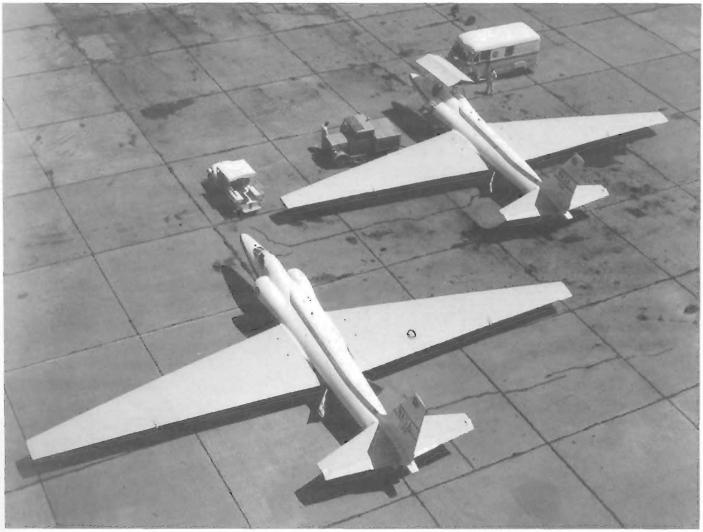
2

Lockheed U-2

The Lockheed U-2 arose from a Design Study Requirement dated 27 March 1953, for a single-seat clear weather reconnaissance aircraft with an operational radius of 1,500 statute miles (2,414km) and subsonic cruise speed at altitudes of 70,000ft (21,335m) or over, carrying a payload of reconnaissance equipment weighing between 100 and 700lbs (45 and 318kg). The reconnaissance equipment was to consist of a variety of camera installations.

Various other stipulations were made, such as no defensive armament and no ejector seat. Defensive armament would be of little use for the mission envisaged and, in the event of a forced landing in non-friendly territory, would be positively embarrassing for the capture or destruction of an armed reconnaissance aircraft would be far more politically damaging than that of an unarmed one. Elimination of the ejector seat was prompted by two factors. For starters, the pilot would stand little or no chance of

Below: After a lengthy USAF career, the U-2C was eventually retired in the early 1980s, leaving NASA with the last examples of this basically first-generation model. Both aircraft are still active, these operating with the Ames Research Center.



survival if he ejected into the hostile environment of the proposed operational altitude, while, secondly, considerable weight saving advantages were gained by its omission. To achieve the altitudes required, weight had to be kept down; specifying that there was to be no ejection seat naturally helped in this direction.

The "Skunk Works"

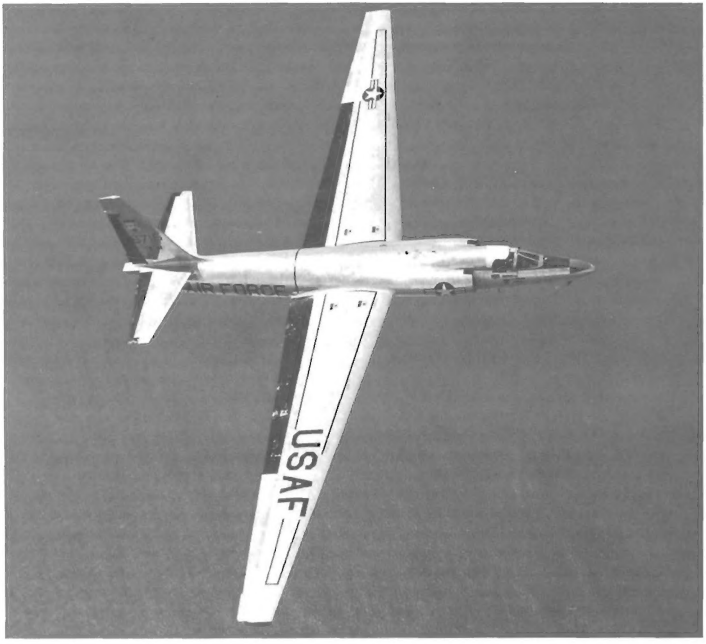
In Lockheed's Burbank, California, facility, was a highly secret department, colloquially known as the "Skunk Works". It was headed by the legendary designer Clarence L. Johnson, who was usually called Kelly, not because of his ancestry, which was Scandinavian, but due to a penchant for green ties. In his capacity as chief of the advanced design bureau, Kelly Johnson was naturally interested in this new proposal and, in May 1954, submitted his solution, the CL-282. Although essentially satisfying the specification, it was rejected for various reasons, not least of which was the choice of engine, which was felt to be inadequate.

At about this time, the American intelligence community was receiving disturbing reports that the Soviet Union was developing a long range ballistic missile delivery system to carry thermonuclear warheads. A means of penetrating the Iron Curtain assumed new urgency and the Central Intelligence Agency (CIA) added its weight to what became known as "Project Aquatone". While all this was going on, the Skunk Works was completely redesigning the CL-282 to incorporate the Pratt & Whitney J57 turbojet, which was felt to have more potential than the previously proposed General Electric J73. The CIA was by now closely involved with the project and, in November 1954, Director Allen Dulles, together with Defense Secretary Charles Wilson, delivered a briefing on "Project Aquatone" to President Eisenhower. Approval quickly followed and the go-ahead for an initial batch of 20 aircraft was given before the end of the month. As a security measure, funding was accomplished through CIA channels, it being agreed that the Agency would be first to operate the type, for which the designation U-2 was adopted. This, in itself, was a classic instance of disinformation for the "U" prefix usually signified utility.

High altitude pros and cons

Ultra-high altitude flight has its own advantages and disadvantages. The main advantage is that at extreme altitude the atmosphere is very thin, offering little resistance to the passage of an aeroplane. Thus, less power is needed to sustain flight. On the other hand, the thin air causes an increase in the stalling speed, and, at these operating altitudes, only a few knots separates the buffet that precedes a stall and the buffet arising from critical Mach number, this phenomenon being colourfully referred to as the

Below: The first U-2 to reach SAC's 4080th SRW was 66696 which was delivered to Laughlin AFB, Texas, in 1957. Unlike the CIA's, SAC U-2s initially operated in a basically natural metal finish.



Above: Displaying the 4080th SRW's shield on the fin as well as a distinguished unit citation ribbon, 68715 served for a time as a HASP-configured U-2A and, rather unusually, featured red flaps, elevators and rudder when this fine study was taken.

"coffin corner". The thin air also reduces the power output of the engine; the J57 is rated at 10,500lb (4,763kg) static thrust at sea level, but this falls to barely 750lb (340kg) of thrust at 70,000ft (21,335m). There is no margin for error and a departure from controlled flight at very high altitude is extremely difficult to recover from.

As if that wasn't enough, there is Armstrong's Line, reached at about 63,000ft (19,200m), where air pressure is insufficient to keep gases present in the human body in solution. The U-2 has a pressurised cockpit, but the pilot must also wear a full pressure suit. If the cockpit pressurisation fails and the pilot loses, for instance, a glove, his blood will appear to boil as the oxygen in it evaporates. This is invariably fatal.

If the engine can deliver just enough power and the life support systems can keep the pilot pressurised, breathing and warm (it is minus 56 deg C up there), the main problem becomes one of obtaining enough lift. The buzzword is aerodynamic efficiency, getting the maximum lift for the minimum drag, for which a high aspect ratio wing is preferable. Aspect ratio is the ratio of the span^2 to wing area, in the case of early U-2s, 10.71. By comparison, the aspect ratio of a modern jet fighter is about three.

A very high aspect ratio was adopted for the U-2 in

order to achieve the required high altitude performance and this gives the Lockheed aircraft its most distinctive feature; the long but narrow wing. The other key factor in the wing design is a low wing loading, which reduces the weight that each square foot of wing surface has to carry, this, in turn, determining the amount of lift it has to generate. Put simply, wing loading is the ratio of aircraft weight to wing area. In early U-2s it was 36.83lbs/sq.ft (180kg/m^2) or about the same as a fighter of 1940 vintage and less than half that of most modern jet fighters.

With the choice of powerplant settled, and the outline configuration determined, the Skunk Works concentrated on translating the concept into hardware. Every conceivable effort was made to keep structural weight to a minimum. There was, of course, no requirement for hard manoeuvring and the structural flight limitations were set at 3g positive and 1½g negative.

New test facility constructed

As a security measure, a new flight test facility was constructed at Groom Lake, a dry lake bed in the Nevada desert, this also being referred to as Watertown Strip and, less specifically, as "the Ranch". In July of 1955, the prototype aircraft, assigned the Lockheed number 001 and the CIA Article Number 341, was airlifted to Groom Lake for final assembly, a process which took about two weeks and which culminated in the start of taxying trials on the 29th of that month. During these, it inadvertently left the ground for the first time, barely eight months since the go-ahead had been given, by any standards a remarkable achievement.

In its general appearance, 001 resembled nothing so much as a jet-propelled sailplane, although this was belied by the polished aluminium finish, broken only by USAF insignia on the intake sides, and, possibly, the number 001 on the fin, although some sources state that this may have been added to the photographs that were released and did not feature on the actual aircraft.

Judged by the standards of the day, the fuselage looked very ordinary, with a near enough circular cross section throughout except where the engine side intakes protruded, ahead of the wing but to the rear of the cockpit.

The intakes were simple, as was to be expected with a firmly subsonic design, and were fitted proud of the fuselage to prevent sluggish boundary layer air from entering. Its very ordinary appearance served to mask the fact that it had a very good fineness ratio, of about 9:1, to minimise drag. The cockpit was set forward and the canopy was faired smoothly into the top of the fuselage, with just the merest suggestion of a protrusion.

The canopy lid was unusual in that it was hinged, rather than sliding, opening to the left, and the prototype carried a canvas sunshield under the canopy. The few photographs released of the first aircraft show it to have had a very high quality finish. This may, of course, have been the result of airbrush work on the photographs, but, as meticulous attention has been paid to reducing drag and as later U-2s all show a high quality finish, it is very probable that this was quite genuine. This apart, the only blemishes on the shiny aluminium finish were what appear to have been a dielectric nose cone and a dark panel to the front nose area which may well have been a camera port.

Not readily apparent was the "Q" bay, a pressurised compartment for reconnaissance equipment located immediately aft of the cockpit. Speed brakes were mounted on either side of the aft fuselage and the extremely close fit was very noticeable. The sole excrescence on the fuselage was a small blade aerial beneath the cockpit. The whole effect of the fuselage was most unremarkable until one looked at the undercarriage which could only be described as different.

Imaginative concept

One of the weight saving stratagems conceived for the CL-282 was the omission of an orthodox undercarriage, take-off being carried out from a wheeled dolly with the ensuing landing being made on retractable skids. This system was not original, having been used by some German jets, notably the Arado Ar-234 bomber, some ten years earlier. Although not a feature of the U-2, the weight saving potential had been very tempting.

A compromise solution was, however, adopted. A retractable bicycle gear configuration was developed, this consisting of a lightweight titanium structure twin-wheel main gear located on the fuselage centreline just ahead of the wing leading edge, coupled

Above: Carrying one of the batch of "civil" registrations allocated to U-2 aircraft of the CIA, the aircraft depicted here in company with an F-104 at Palmdale is believed to be a U-2B.

with a steerable twin tail wheel, small and with solid rubber tyres, towards the rear of the fuselage.

To balance the U-2 for take-off, detachable outrigger wheels were mounted at about mid-span on the wings. Once airborne, these wheels or "pogos" fell free, landing being a question of balancing on the bicycle gear for as long as possible. When one wing or the other finally dropped, it was protected by a skid mounted on the wing tip. As landing speeds were very low by the standards of the day, this was a perfectly feasible proposition.

The tail surfaces were very conventional, rather angular in shape, with a high aspect ratio and employing an orthodox rudder and elevators. What appeared to be a pen-nib fairing was featured at the point where the trailing edge of the fin met the fuselage at the engine nozzle, presumably to reduce either base drag or limit buffet.

The most striking feature of the U-2 was the wing, with an enormous span of 80.17ft (24.36m). Of lightweight construction, incorporating three main spars held together with aluminium tube lattice ribs, it housed most of the internal fuel, although there was also a relatively small tank in the main fuselage to feed the engine, this in turn being fed by the wing tanks. The design of the wing was a very fine balance between high lift and structural weight, but as hard manoeuvring was not a requirement, considerable latitude could be allowed for flexing. A full complement of high lift devices was incorporated; flaps occupy roughly two-thirds of the trailing edge, with ailerons taking up all of the remaining length, located outboard. To accommodate the considerable wing flexing, the flaps are in four sections on each wing and are driven by a flexible shaft with hydraulic actuation. The maximum flap setting is 35 deg. On the leading edges are what are called stall strips, a type of slat which can be deployed to improve low speed handling. The stall strips are about 2.63ft

(80cm) long and are located at the one-third span position, working outward from the wing root.

An inherent defect of the high aspect ratio wing is that its gust reponse is very high. This is important in low level flight for, while the U-2 is optimised for ultra-high altitude work, it still has to take-off and land, a process which entails traversing turbulent air near the ground. This makes it tricky to handle, particularly on final approach where the speed is decaying, and Lockheed sought to alleviate the worst effects with a gust control system, designed to move the aerodynamic centre of pressure forward and thus reduce the vertical structural loads on the horizontal flight surfaces. Selected manually by the pilot from the cockpit, the gust control system deflects both flaps and ailerons by ten deg. Naturally, the latter can still be used for lateral control; their maximum range of travel being 16 deg up and 14 deg down.

The U-2 gets airborne

The first official flight (the earlier unintentional hop did not count), was made from Groom Lake on the afternoon of 1 August 1955 with project chief test pilot Tony LeVier at the controls. The 45-minute flight was uneventful until the time came to land. Previous discussion had determined that a flat approach was to be made, touching down on the main gear first; a procedure that LeVier was not entirely happy with. Like the sailplanes that it so closely resembled, the U-2 had a distinct tendency to "float". On this occasion, the main gear touched twice and each time the U-2 bounced back into the air. Consequently, LeVier was forced to adopt the "tail-dragger" technique, flaring out just above the runway and letting the aircraft touch down tailwheel first as it stalled. It then settled fairly smoothly onto the main gear.

CIA involvement grows

The test programme initially went smoothly and the operational envelope was gradually extended. Three more aircraft had reached Groom Lake by the end of the year and the first batch of CIA pilots duly arrived for conversion to type early in the new year. These were all former USAF pilots and had been specially selected, key qualities being experience and above average flying ability, for it was now acknowledged that the U-2 was a tricky aircraft to fly, both at the top end of the envelope and particularly during the landing approach.

The pilots remained in the service, albeit under cover, officially being employed by Lockheed and this selection and camouflage process was to continue for many years. One distinguished Air Force pilot, due for an unwelcome ground posting, remarked: "I got a phone call one night which said 'How'd ya like to keep flying?' I said yes and just dropped out of circulation for the next five years."

The deliberate security smokescreen that quickly enveloped the U-2 has had the effect of giving rise to myth and legend. So effective has this been that it still remains today, after the passage of some 30 years, well nigh impenetrable.

Below: The U-2's extremely slender wing is displayed to advantage in this near head-on view of U-2D 66722 overflying its home base at Edwards, California, in the mid-1960s while assigned to the 6512th Test Squadron. This aircraft is now part of the USAF Museum collection at Wright-Patterson AFB, Ohio.

3

U-2 Variants

Total production of all variants will barely surpass the 100 mark and few, if any, aircraft built in such small numbers have been subject to quite so many variations. While it may be an exaggeration to say that no two U-2s, even of the same sub-type, look alike, it is not overstating the case by much.

Few U-2s have served for any length of time without being converted or upgraded—even fewer can have escaped having antennae arrays added, then removed or replaced by a different set at a later date and it is thus virtually impossible to be dogmatic about individual aircraft. The waters have been further muddied by aircraft being switched between the CIA and the USAF, these carrying at various times CIA Article numbers, USAF serial numbers, civil registrations and NACA/NASA "identities". Further confusion arises from the fact that spurious markings have been applied from time to time and that some photographs have been carefully retouched with false information. Infuriating though this may be to the modeller, we should give credit to the Americans for a sterling security job.

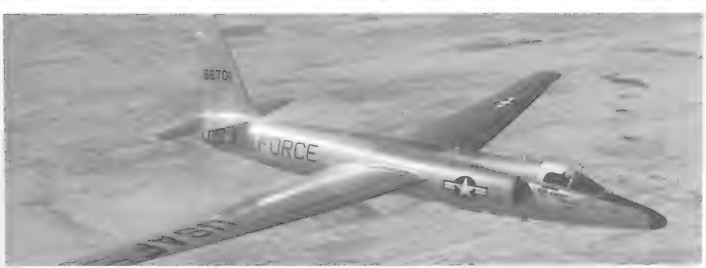
Thus, while the following details are based on the best available information, they should not be taken as definitive. Hopefully they are accurate.

U-2 One prototype built, given dual identity as CIA Article number 341 and Lockheed in-house number 001. No Air Force serial number assigned. This aircraft crashed in April 1957 when the faceplate on Lockheed test pilot Robert Sieker's partial pressure suit failed with fatal consequences.

U-2A This was the first production model, being a lighter and more sensitive aircraft than later variants, which suffered from the inevitable weight increases attendant upon the normal development process. The canvas sun screen inside the canopy was deleted, its place being taken by a white-painted area on the inside of the plexiglass. The pen-nib fairing at the rear end was replaced by a housing that could be used either for sensors or for a 16ft (4.88m) diameter braking parachute. The initial order was apparently for 20, but it seems likely that all of the first 48 aircraft (56-6675 to 56-6722) were laid down as U-2As although they may not necessarily have been completed as such.

Most aircraft were revised to take an ejector seat and the uprated J57-PW-37A engine, these two

Below: Another long-lived aircraft, 66701 initially operated with the CIA before being turned over to Air Force Systems Command for use from Edwards on a variety of test projects. Subsequently assigned to the 100th SRW and the 9th SRW, it survives in retirement with the SAC museum at Offutt AFB.



Above: Reinstated in production yet again, the newest aircraft include a brace of two-seat TR-1B trainers, the first of which is seen here while on a pre-delivery test flight.

modifications commencing in 1957. Some U-2As flew in the High Altitude Sampling Program (HASP), 1957–65, under the designation WU-2A.

WU-2A HASP aircraft as previously described, an initial batch of five examples joining the 4080th SRW in September 1957. Apparently modified from existing U-2As, they were later joined by other similarly configured aircraft, at least a dozen machines being linked with the HASP effort between 1957 and 1965. A gas sampling intake and valve was installed in the extreme nose, which was of aluminium, while a fairing housing a particle sampling inlet was mounted slightly in front of and below the port engine intake. HASP-dedicated aircraft include the following Air Force serial numbers: 56-6681, 56-6690, 56-6696, 56-6700, 56-6705, 56-6712, 56-6714 to 56-6718 and 56-6953, the latter having originally been completed as a U-2D.

U-2B This was a variant modified to carry a heavier payload, with a stronger structure for improved fatigue life and powered by the J75-PW-13 engine which gave considerably more thrust than the J-57. The U-2B also possessed greater range than the U-2A while some aircraft were modified to take a dorsal fairing containing extra sensors.

As far as is known, the U-2B arose from conversion of existing U-2As, aircraft subjected to this process apparently including 56-6679 to 56-6698, 56-6701, 56-6702 and 56-6712, although it is possible that a few of these progressed straight from U-2A to U-2C configuration. Most, if not all, of the surviving U-2Bs are believed to have been transferred to the Taiwanese Air Force at a later date.

U-2C Engine problems with the J75-PW-13 were solved with the modified -13B as used in the U-2C. The U-2C also had greater fuel capacity and a slightly longer nose to house sensors. The dorsal fairing adopted for the U-2B was fairly standard on this model, as were enlarged engine intakes.

Once again, it appears that production of the U-2C was accomplished by conversion, numerous U-2As, U-2Bs and a few U-2Ds being reconfigured in this way. It should, at this point, be apparent that the designation suffix bore little or no relation to either chronological order or a continuous process of development. Conversions from U-2As are 56-6700, 56-6704 to 56-6706, 56-6709, 56-6712, 56-6714 and 56-6716 plus possibly 56-6708. Conversions from U-2Bs are 56-6692, 56-6694 to 56-6698, 56-6701 and 56-6702. Serial numbers 56-6953 and 56-6954 were converted from U-2Ds, while 56-6680, 56-6703 and 56-6707 were previously U-2Fs. Finally, 56-6681 and 56-6682 had been U-2Gs while 56-6719 has also been identified as a U-2C although its background is not known for certain.

U-2CT The high attrition rate resulting from accidents occurring either at high altitude in "coffin corner" or on final approach necessitated acquisition of a dual control trainer version. This need was met by the U-2CT, which features a second, raised cockpit behind the first.

Two aircraft were rebuilt from damaged items and were reported to have used parts from write-offs to

Above: Essentially serving as a prototype for the TR-1, NASA 706/80-1063 is truly unique, for it is the only example of the ER-2. It now operates from Ames, California.

supplement the main airframe. The first was Air Force serial number 56-6953, previously a U-2D, which appeared in 1972, while the second was 56-6692, previously a U-2C. This was produced in 1976.

U-2D This variant was a U-2A type but with special Q-bays designed to accommodate either a second crew member or special unspecified equipment. A total of seven U-2Ds was produced; comprising five new-build aircraft and a couple of conversions. The new build serials were 56-6951 to 56-6955 while the modified aircraft were 56-6721 and 56-6722. Equipment configuration varied significantly, each of these aircraft effectively being a "one-off" conceived and produced to satisfy very different mission requirements.

U-2E This variant contained advanced (for the day) ECM systems in the tail area and was reportedly slightly heavier and of lower performance than the U-2A and U-2B models from which it evolved. Conversion, mainly of U-2As plus a few U-2Bs, was again the order of the day, involving some 18 aircraft in all. Assigned exclusively to CIA missions, no identification of individual aircraft is possible.

U-2F This designation was given to at least four U-2s which, in 1962, were modified for in-flight refuelling, with a receptacle mounted just in front of the dorsal spine. Air Force serials of the four known examples were 56-6680, 56-6687, 56-6688 and 56-6703, all later being reconfigured as U-2Cs.

One of these aircraft was later configured for the Target Radiant Intensity Programme (TRIM), in an all-black paint job with white dome-shaped sensors mounted fore and aft dorsally connected by a large black fairing.

U-2G Two U-2s were minimally modified for aircraft carrier operations in 1964. The work consisted of fitting bolt-on arrester hooks with a little local strengthening, minor alterations to the struts of the main gear, adding wing spoilers to dump lift and providing larger wingtip skids. Air Force serials assigned were 56-6681 and 56-6682. It is believed that these aircraft had been updated to U-2B standard before becoming U-2Gs and they were later converted to U-2Cs.

U-2J It has been widely rumoured that this designation was allotted to "production-configured" U-2Gs, but no firm information has ever been released.

U-2N Rumoured designation of major redesign, possibly pertaining to what evolved into the U-2R. Like the U-2J, it may never have existed.

U-2R This represented a major airframe redesign which retained the well-proven J75 engine. It evolved in response to two factors. Firstly, the number of original airframes still in the inventory continued to decline. Operational accidents and hostile action had, inevitably, had some impact while the design of the U-2A, in its efforts to reduce structural weight, had culminated in an airframe with a relatively short fatigue life. In view of that, by the mid-1960s, many airframes were reaching their allotted span.

Secondly, as is inevitable with any operational aircraft, the weight had increased, and, in many

cases, the drag also, as new sensors and antennae, drop tanks and fuel/sensor pods were added. These extras naturally impaired high altitude performance and later U-2 models simply did not have as good a capability as the original U-2A.

The U-2R was a partial solution to these problems, being a larger and heavier machine than its predecessors. Basically, it could carry heavier loads considerably farther with a good high altitude performance and an expanded speed margin at "coffin corner." The production contract was placed in August 1966, the type flew for the first time on 28 August 1967 and it entered service with the CIA late in 1968.

Externally, it was still obviously a U-2, but the wing span had been increased by 23ft (7.01m) and wing area by 400sqft (37.17m^2). The aspect ratio remained the same, but the lift/drag ratio was improved. Spoilers were incorporated in the upper wing surfaces; those outboard being for lateral control while the inboard ones were for lift dumping. The wings were virtually fully "wet", giving increased fuel capacity. Indeed, only the outboard panels, which could be manually folded for ease of ground handling and to enable it to fit aircraft carrier lifts, were dry. The fuselage was redesigned and was larger, with more avionics bays, although fineness ratio actually improved by just over 10 per cent. The cockpit was larger than on previous U-2s and could accommodate a pilot wearing a full pressure suit, as opposed to the partial pressure suits previously worn. A zero/zero capability ejection seat was also included for the first time. The leading edge stall strips were increased in length and provision was made for the carriage of large wing pods. The U-2R was always intended to be carrier compatible and local fuselage stressing to take arrester gear attachments was built in from the start. The engine nozzle was revised and also the shroud against infra-red detection and homing devices.

These and other changes resulted in a marked increase in weight and the main landing gear was strengthened to cope with this. Improvements in brake technology permitted the use of orthodox disc brakes on the main wheels, unlike earlier U-2s which had utilised dual disc brakes on each wheel.

The tail surfaces were also revised and enlarged. Carriage of the wing "superpods" caused buffeting in certain flight regimes and very noticeable stiffening ribs were added to the horizontal tails of some, if not all, U-2Rs as a retrospective measure. Radar Homing And Warning (RHAW) systems were also added to most U-2R wing skids.

US Air Force serial numbers allotted to the U-2R extended from 68-10329 to 68-10353, although there is good reason to believe that only 17 were built, production actually terminating at 68-10345.

Like other variants, the U-2R has produced its fair

Below: Virtually indistinguishable from the U-2R model, the TR-1A is in fact optimized for tactical rather than strategic operations. This is the second production example, 80-1067.

share of one-offs. These include 68-10336, which featured an extended nose housing equipment which may be associated with the Hughes Advanced Synthetic Aperture Radar System (ASARS), later carried by the TR-1A, while, in 1976, number 68-10339 was reportedly used to flight test a Hughes radar scanner housed in an inflatable radome. Earlier, this aircraft had served as the U-2EP-X (which see) and in late 1984 it was reported that a U-2R had been modified to carry a dorsal AWACS radome mounted on a pylon located near the wing centre section. It is possible that this may be the same aircraft. The radome is of a non-rotating type and is reported to be similar in appearance to that carried by the Grumman E-1B Tracer, an aircraft long vanished from the inventory.

U-2EP-X More correctly known as the U-2 Electronic Patrol-Experimental, this variant arose from a USN requirement to verify the effectiveness of certain sensors in monitoring shipping from high altitude; detecting submarine schnorkels, and the possible carriage of the Condor anti-ship missile. Undertaken during the 1972-73 time-frame, it employed two modified CIA U-2Rs, one of which was 68-10339. The conversion was carried out with Navy funding and, apart from the special avionics, involved modifications to the radome, wing pods and some sensor bays. The wing pods carried were of an unusual slipper configuration. Aircraft 68-10339 was later used in TR-1 equipment trials.

ER-2 This aircraft was purpose-built for NASA and, although assigned the Air Force serial number 80-1063, carries no military kit whatsoever. In essence, it is the aerodynamic prototype of the TR-1 and it first flew on 11 May 1981. Initially tested in a natural metal finish, relieved only by NASA titles and the number 706 on the fin, it has since been painted in a most attractive livery, basically comprising white upper surfaces with a black anti-glare panel in front of the cockpit and thin black strips at the base of the fin and rudder. Undersurfaces are grey, the ER-2 having a horizontal blue cheat-line with a white and grey border. NASA inscriptions appear on the fin in red, with 706 in black, while the full USAF serial number (80-1063) is displayed on the air brake.

TR-1A As already noted, the original utility designation had been adopted purely as a cover for the strategic reconnaissance role. The "TR" designator, however, stands for tactical reconnaissance and, while the TR-1 certainly has a tactical role, it is interesting to note that it is actually assigned to Strategic Air Command.

Above: One of two U-2Rs modified to examine a Navy requirement for an electronic patrol aircraft to monitor shipping from high altitude, the U-2EP-X was extensively evaluated by that service in 1972–73.

Basically, the TR-1A is little more than a U-2R adapted to carry different sensor packages such as ASARS and PLSS. Externally, it is virtually impossible to tell the difference between the two, although all TR-1s carry the same ECM pods on the wingtip skids, plus a further one on the trailing edge of the starboard wing, as indeed does the U-2R.

One difference is supposed to be a split in the trailing edge flaps to accommodate the superpods, but since this is also a feature of pod-configured U-2Rs, that's not a great deal of help.

Leaving aside such weighty matters, it is known that TR-1 production commenced at the end of 1979 and that the first flight took place on 1 August 1981. SAC originally anticipated the procurement of 35 aircraft, but it now seems likely that only 26, including the two TR-1Bs and some U-2Rs, will be built. TR-1A/U-2R serial numbers seen to date run from 01066 to 01083 although it is not possible to establish which aircraft were obtained in which fiscal year.

TR-1B The TR-1B is a two-seater training version of the TR-1A, with an elevated cockpit occupying the Q-bay area. Unlike the TR-1A, which is painted matt black, with the serial number on the fin in red, the TR-1B has a white finish broken only by an anti-glare panel in front of the cockpit. Standard USAF markings are carried and serial numbers assigned to the two aircraft are 80-1064 and 80-1065. The first flight took place on 23 February 1983 and both aircraft were delivered to Beale AFB, California later that year.

4
Colours and Markings

Colours and markings carried by the U-2 at different times are at least as varied as the sub-types. The confusion arising from the numbering system has already been touched upon and it seems certain that we are in for a long wait for clarification since Lockheed's U-2 files are not due to be declassified until 2011. So far, reference has been made to the Air Force serial numbers but it should be noted that other numbering systems have been used. In the early days, the Lockheed production number was used, as, on rare occasions, were the three-digit CIA Article numbers. Both NACA and NASA numbers have also been seen, although some of these have only been noted on photographs and reasonable doubt exists as to their authenticity in many cases.

The waters have been further muddied by the allocation to Lockheed by the FAA of the civil registrations N800X to N810X, ostensibly for use during modification programmes although they were often carried by CIA-operated aircraft engaged on clandestine missions. Further confusion arises from the fact that many of these registrations have been carried by more than one aircraft. Furthermore, U-2s operated by the Taiwanese Air Force carried their own locally-applied serial numbers while on attachment.

Basic paint schemes

The basic paint schemes carried by the U-2 also varied widely. In some cases, where Air Force serial numbers have permitted positive identification, it is known that certain aircraft have changed colour at least four times. It is therefore impossible to give definitive information on colour schemes and the following is intended only as a general guide. The modeller is advised to obtain a photograph, preferably in colour, if he seeks authenticity and then be guided by the following notes, which cannot, through reasons of space, be comprehensive.

Many U-2s retained their natural aluminium finish for a considerable period, generally highly polished, while others, including at least one U-2R, made their early flights in bare metal before being painted. Other colour schemes known to have been applied include overall grey; overall black, which was semi-gloss on a few early machines before adopting the matt sooty black familiar today; a special two-tone grey scheme utilised for operations from Wethersfield, England in 1975 and, last but by no means least, white.

Apart from the prototype, all models had an anti-glare shield painted on the inside of the plexiglass canopy in white. This persisted for many years after the basic black colour was adopted and it was not until much later that it also became black. Nor was the all-black scheme always uniform in hue, photographs showing many instances of black aircraft flying with unpainted or different colour replacement panels, while the second TR-1A, 80-1067, has been seen with a darker panel in the middle of the port wing and a very dark panel on the outer starboard wing.

Below: Photographed at Palmdale, California, shortly before the official roll-out ceremonies, aircraft 80-1066 was the first TR-1A to be built and presently serves with the 9th SRW.

Most of the natural metal, white, and some of the grey aircraft sported a matt black anti-glare panel just in front of the cockpit, but even this did not follow a standard pattern. In some cases it stopped short at the nose cone, in others it included the entire cone, and in yet further examples it covered just a part, usually the upper half of it. Probably the only point in common with all paint schemes concerns the intakes, which are painted white internally as an aid to preventing ingestion of foreign objects.

Warnings and notices

Warning signs and equipment information are yet another area of complete non-standardisation. Some of the early aluminium-finished aircraft had a certain amount of stencilling on the skin, whereas the painted machines do not appear to have had this. Types up to and including the U-2R sported yellow-over-black rectangular RESCUE and red triangular DANGER signs on the left side beneath the cockpit on some aircraft; others featured just the red triangle, while others had nothing at all.

The base finish colour seems to have had no influence on this, nor on the dull red band around the rear fuselage level with the engine compressor which appears randomly. The "no step" lines on the wing upper surface are another case in point. They have been observed in dull red on both black and aluminium U-2s and in pale yellow on at least one black U-2B, although in most cases they are not present at all.

One aircraft assigned to the USN—possibly but not certainly one of the two U-2EP-Xs—showed red chevrons on the front fuselage ahead of the intakes, on a basic white finish. This aircraft had NAVY titles on the rear fuselage in black letters. If it was indeed the second EP-X, this simply illustrates the diversity of U-2 paint schemes, for the other, positively identified machine, was all-black and carried the NAVY legend in white.

Variety at Edwards

Some of the more colourful U-2s were those attached to experimental units at Edwards AFB in California. These were normally painted for visibility rather than invisibility but a variety of finishes were applied to aircraft assigned to the 6512th Test Group at this always interesting base. In the final years of operation, the two aircraft which remained active appeared in a basically white scheme with a red lateral stripe on the fuselage and the AFFTC logo in red on the fin, Air Force insignia not being carried. Other U-2s based at Edwards appeared in varying combinations of dayglo red, natural metal, black or white, usually in conjunction with standard USAF insignia and often with photographic reference markings. As an example, U-2D 56-6954 was seen in a black and silver finish with black resolution circles on the port side of the fin and a black sun visor area. Perhaps the only standardisation that may now be said to exist with regard to USAF aircraft is that all two-seat trainers are basically white, while all single-seaters are black. Broadly speaking, though, it is probably fair to remark that, from a historical viewpoint, the only rule is that there is no rule.

Many early U-2s carried standard USAF insignia on both intakes and the left top and right underside

Below: Seen in its final colour scheme and external configuration, U-2 66721 of the Air Force Flight Test Center at Edwards AFB remained active until just before the end of 1980.

of the wings, supplemented by U.S. AIR FORCE inscriptions in large black letters on both sides of the rear fuselage and USAF titles on the wings, reversed to the insignia. This was generally on the natural metal or light finished aircraft while it was rare, although not unknown, for black aircraft to carry these markings. When they did, the lettering was in white. On occasion, only the insignia was carried. Today, the TR-1A and U-2R carry no national markings but both TR-1Bs do display a full set.

Aircraft identities

The individual aircraft identity is normally presented on the fin, often in the form of the Air Force serial number, in black on light-coloured aircraft and in white on early black aircraft, but latterly in dull red. CIA missions were sometimes flown with USAF serials, but more often with the misleading "N" numbers, painted in white on black and sometimes with three digit NACA or NASA numbers, these almost certainly being of a wholly spurious nature.

On NASA's own aircraft, NASA serials are also used, but it is normal for these machines to have the USAF serial number on the rear of the fuselage.

Where Air Force insignia is worn, but where the legend U.S. AIR FORCE does not appear on the rear fuselage, it is often to be found on the fin, just above the serial number.

When applying Air Force serial numbers, it appears to be normal practice to omit the first numeral and the hyphen, so that, for example 56-6681 would appear as 66681. The U-2R, however, does not follow this pattern for it was ordered in a fiscal year when more than 10,000 aircraft and missiles were procured—thus, these carry only the five digits after the hyphen, viz 10329 and 10336.

Individual aircraft markings have not been uncommon. Distinguished Unit Citations were often acknowledged by painting the ribbon colours on the fin, while cartoon characters such as Smokey Joe and Snoopy have appeared from time to time. Temporary deployments to Australia were also once marked by a red kangaroo, either below the cockpit sill or on the wingtip skid. Occasionally, unit badges have also been worn. Currently, however, the trend appears to be one of total anonymity.

Below: The different colour schemes and physical appearance of these two U-2s provides graphic evidence of the variety of configurations adopted by aircraft assigned to the 6512th TS.

5

U-2 Performance

The performance of the U-2 family has always been a matter of debate. What was never in doubt was that it flew extremely high at moderate speeds for long distances. Even today, though, Strategic Air Command is extremely coy about quoting numbers.

At the time of writing, the latest USAF Fact Sheet released by SAC headquarters at Offutt AFB is 85-13 for the U-2 and 85-39 for the TR-1. The U-2 model referred to is the U-2R, and, perhaps unsurprisingly, the same figures are given for both types. These are: speed 430 miles/hr (692km/hr); ceiling above 70,000ft (21,335m) and range more than 3,000 miles (4,828km).

When one considers that non-stop flights are periodically made from Beale AFB in California to RAF Alconbury in England, a distance of roughly 5,600 nautical miles (10,400km), it is reasonable to assume that, perhaps justifiably, they are holding something back. In fact, there is reason to suspect that the figures quoted are much nearer to those of the early model U-2s than the very latest types.

Climb procedures

On finals, the TR-1A resembles nothing so much as a large glider as it swoops gracefully from the sky and settles gently on the runway, but this impression is belied on take-off when it hauls into a steep climbing turn, trailing thunder from its J75 engine. Then, it looks purposeful and dynamic, and, in its black livery unbroken by insignia, rather sinister. The large "superpods" add to the air of menace.

The initial climb is made to an altitude exceeding 55,000ft (16,763m) at which point it is throttled back to a steady Mach 0.72. As fuel is consumed and the aircraft becomes lighter, it gradually drifts higher until the desired operating altitude is reached. This altitude will depend on the mission, the load carried and the ambient air temperature (the colder it is, the higher the aircraft will go). As a generalisation, though, it will take something over half-an-hour to reach 65,000ft, (19,811m), during which time some 90 nautical miles (167km) will have been covered.

Approximate performance data based on the best information available from open sources is given in the accompanying table. It will be noted that the figures differ considerably from the SAC data.

PERFORMANCE DATA

	U-2A	U-2B/C/D	U-2R	TR-1A
V max (kt/km/hr)	429/795	459/850	443/821	430/797
Ceiling (ft/m)	75,000 (22,859)	70,000 plus (21,335)	75,000 (22,859)	75,000 (22,859)
Range naut mls (km)	4,125 (7,644)	4,125 (7,644)	5,200 (9,655)	5,200 (9,655)
Internal fuel JP-7 lbs/kg.	8,686 (3,940)	8,686 (3,940)	20,398 (9,253)	20,398 (9,253)
External fuel JP-7 lbs/kg	1,316 (597)	1,316 (597)	NIL	NIL
Wing loading at TOGW lb/ft^2(kg/m^2)	36.83 (179.85)	39.95(U-2C) (195.08)	41.00 (200.20)	41.55 (202.89)
Power loading at TOGW	0.51	0.71(U-2C)	0.41	0.41

It should, of course, also be noted that at least one U-2A has been taken up to 81,000ft (24,688m) under ideal conditions, while it is widely rumoured, and often quoted, that the TR-1A can attain 90,000ft (27,430m). However, a quick examination of the respective wing and power loadings of the two types makes the latter seem unlikely. In clean configuration with 50 per cent fuel, the U-2A probably retains a comfortable margin in both departments, unless, as is always possible, the TR-1A has hidden, and highly classified, talents.

Take-off speeds depend on weight, varying with model and loading between 80 and 112kt (148 and 207km/hr), while stall speeds at TOGW vary between 70 and 97 kt (130 and 174km/hr). All models have, as would be expected, an excellent gliding capability, typically being able to travel around 200 nautical miles (370km) from an altitude of 60,000 ft (18,287m), and the fuel minimum safety margin is very small, being of the order of 658lbs (298kg).

DIMENSIONS

	U-2A	U-2B	U-2C	U-2CT	U-2D	U-2E	U-2F	U-2G	U-2R	U-2EPX	ER-2	TR-1A	TR-1B
Span ft	80.17	80.17	80.17	80.17	80.17	80.17	80.17	80.17	103.00	103.00	103.00	103.00	103.00
m	24.43	24.43	24.43	24.43	24.43	24.43	24.43	24.43	31.39	31.39	31.39	31.39	31.39
Length ft	49.72	49.72	49.72	49.72	49.72	49.72	49.72	49.72	62.75	62.00	62.75	62.75	62.75
m	15.15	15.15	15.15	15.15	15.15	15.15	15.15	15.15	19.13	18.90	19.13	19.13	19.13
Height ft	15.17	15.17	15.17	15.17	15.17	15.17	15.17	15.17	16.00	16.00	16.00	16.00	16.00
m	4.62	4.62	4.62	4.62	4.62	4.62	4.62	4.62	4.88	4.88	4.88	4.88	4.88
Wing Area ft^2	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0
m^2	55.74	55.74	55.74	55.74	55.74	55.74	55.74	55.74	92.90	92.90	92.90	92.90	92.90
Aspect ratio	10.71	10.71	10.71	10.71	10.71	10.71	10.71	10.71	10.61	10.61	10.61	10.61	10.61

WEIGHTS

Empty lb	12,000	13,000	13,870	14,120	14,200	14,000	14,170	14,375	15,100	15,500	14,500	15,500	15,750
kg	5,443	5,897	6,291	6,405	6,441	6,350	6,428	6,520	6,849	7,031	6,577	7,031	7,144
Max T.O. lb	22,100	23,100	23,970	23,970	24,300	24,100	24,270	24,475	41,000	41,300	40,300	41,300	41,550
kg	10,025	10,478	10,873	10,873	11,022	10,932	11,009	11,102	18,598	18,734	18,280	18,734	18,847
Wing Load at Take-off Gross Weight													
lb/sq.ft	36.83	38.50	39.95	39.95	40.50	40.17	40.45	40.79	41.00	41.30	40.30	41.30	41.55
kg/sq.m.	179.84	188.00	195.08	195.08	197.76	196.15	197.52	199.18	200.20	201.67	196.78	201.67	202.89
Power Load at Take-off Gross Weight													
	0.51	0.68	0.71	0.71	0.70	0.71	0.70	0.69	0.41	0.41	0.42	0.41	0.41
Engine	J57-PW-37	J75-PW-13	J-75-PW-13B and all further variants										
Static Thrust													
lb	11,200	15,800	17,000	and all further variants									
kg	5,080	7,167	7,711	etc									

With minimum fuel on board, the wing loading is very low indeed; under 23lbs/ft^2 (112kg/m^2) for the U-2A and slightly less for the TR-1A. Stall speeds at these loadings would probably be less than 50kt (93km/hr). The take-off run is about 1,200ft (365m) but the landing distance required is more than double this; the speed brakes being ineffective at low speeds, while the aircraft itself has a low drag factor. The braking prachute reduced the landing run considerably on early models, but its compartment was utilised for sensors on later variants. This is of little import, as the span between the outriggers is such that only a wide, and therefore by the way of things long, runway can be used.

Below: The novel undercarriage is all too evident in this fine view of a U-2R poised above Palmdale's runway. Downturned wing-tip skids eliminate the risk of serious damage to the structure when landing, these being a feature of all U-2s and TR-1s.

6

The U-2/TR-1 in Service

The cover story put about when the U-2 entered service was that it was an innocuous weather research machine used by NACA, or NASA as it became in 1958. In fact, it did carry out invaluable civilian research into such aspects as weather, clear air turbulence and the surveying of earth resources, in addition to work connected with the space programme, but NASA did not get its hands on a U-2 until as late as April 1971. These activities are, however, outside my brief, which is military applications.

With the initial batch of pilots having converted on to type, the first CIA detachment was formed in April 1956. Under the cover provided by fictional designation as the 1st Weather Reconnaissance Squadron Provisional (WRSP-1), the first two U-2As were air-freighted to RAF Lakenheath where they were assembled and test flown. The political climate in England was not propitious at the time and WRSP-1 soon moved to Wiesbaden in West Germany, where it prepared to make the first overflights of the Soviet Union.

"Operation Overflight" begins

The first overflight took place on Independence Day, 4 July, although whether this was significant or not is a matter of speculation. The U-2A selected for this mission—CIA Article No. 347, later 56-6680—overflew Moscow before turning north to Leningrad and returning along the Baltic coast. This flight proved the validity of the U-2 as a reconnaissance vehicle and its ability to penetrate defended areas at high altitudes. Notwithstanding a setback on 17 September when a U-2A flown by Howard Carey crashed near Kaiserslautern, killing the pilot and causing a hiatus in the missions to preserve security, four more overflights were made during the next four months.

Soviet reaction to the first mission had been a deafening silence; later incursions were greeted with furious, although secret, protests through diplomatic channels. The Russians could watch the U-2 progress on radar for long periods but could do nothing to hinder its passage and a vociferous public protest would simply have revealed the inadequacy of their air defences to the world in general.

In fact, U-2 surveillance was not confined to the Warsaw Pact countries. In September of the same year, for instance, information was gathered on the dispositions of the British and French fleets in the Mediterranean, while the Middle Eastern situation was also closely monitored. This, it will be remembered, was shortly before the Suez crisis of 1956.

The U-2 reaches Turkey

The other significant event of that year was the establishment of Detachment 10/10 under the cover of WRSP-2 at Incirlik, in Turkey, in August. Shortly after, in February 1957, WRSP-1 moved to Giebelstadt, only to merge later in the same year with WRSP-2. Thus, Incirlik now became the main CIA U-2 base although smaller operating locations (OLs) extended from Pakistan to Germany to Norway. By the end of 1959, some 30 overflights had been made, but many more stand-off sorties had been completed, with the U-2 remaining over friendly or neutral territory from where it monitored various emissions, or, after Soviet nuclear tests, gathered radioactive gases and particles from the upper atmosphere for analysis. Almost inevitably, though, the most valuable missions had been the overflights which revealed a great deal about the Soviet ICBM programme. From 1958, a third unit, WRSP-3, had been based at Atsugi, Japan.

Meanwhile, the USAF had also begun to operate the type, receiving its first (56-6696) at Laughlin AFB, Texas on 11 June 1957. The unit chosen to operate the type was the 4028th Strategic Recon-

Above: Soviet missile test facilities such as this one were among the installations which were closely monitored by Central Ingtelligence Agency U-2 aircraft between 1956 and 1960.

naissance Squadron (SRS) which formed part of the 4080th Strategic Reconnaissance Wing (SRW). As has been the case ever since, operational USAF U-2 units formed part of Strategic Air Command resources.

The USAF had an on-going High Altitude Sampling Programme (HASP) which had commenced some three years earlier to investigate distribution of by-products generated by nuclear explosions on a world-wide basis. When, in September 1957, five WU-2As were delivered to Laughlin, they were all assigned to HASP. Over the next few years, aircraft of the 4028th SRS regularly deployed around the globe on this mission, which kicked off in Puerto Rico and took in Argentina, Alaska, Hawaii, Guam, Okinawa, Panama and Australia on the way.

The next Air Force to operate the U-2 was that of Taiwan. With active CIA assistance, they commenced overflights of mainland China on 6 December 1958. Generally painted black, these aircraft often displayed small Nationalist Chinese insignia on the rear fuselage near to the speed brake.

As previously mentioned, the U-2 was a difficult aircraft to fly and ultimately accumulated what was almost certainly the highest accident rate of any military aircraft in history. By the end of April 1960, at least a dozen had been lost to various causes and many more had been damaged. As yet, though, not one had been lost to hostile action, but this was about to change in most dramatic fashion.

If it was ironic that the first overflight of the Soviet Union had been made on American Independence Day, it is probably fair to remark that it represented a kind of justice when the Russian air defences eventually succeeded in shooting down a U-2 on May Day, 1 May 1960. Flying what was believed to be U-2B 56-6693, Agency pilot Francis Gary Powers took off from the OL at Peshawar in Pakistan, to overfly the Soviet ICBM test sites at Plesetsk and Sverdlovsk, which, quite naturally, were heavily defended. Other objectives were Kirov, Archangel and Murmansk, after which the flight path was to cut across northern Finland and Sweden to end at Bodo, Norway, a distance of around 3,300 nautical miles (6,115km).

Lack of Soviet success

The Soviet defences had previously attempted to shoot down a U-2 but thus far without success. At 70,000ft (21,335m) it was immune to the fighters of the day while the SA-2 *Guideline* surface-to-air-missile lacked manoeuvrability in the attenuated air at high altitude.

Nevertheless, the Russians were bound to try again and it should not be forgotten that virtually the entire Soviet air defence system was free to concentrate its efforts on one lone intruder. Fighters were

Below: Seen while on trial for espionage in the Soviet Union, Francis Gary Powers precipitated an international incident when his CIA U-2 was brought down near Sverdlovsk on 1 May 1960.

Above: This plan view of a Russian bomber base is typical of the first-class material gathered during "Operation Overflight", in which Agency U-2s regularly penetrated Soviet airspace.

scrambled but, as usual, they could not get up high enough. A zoom climb might have put them in position, but it would have called for an incredibly accurate piece of both flying and controlling. It is believed that several missiles were also fired without success. Then, as the U-2 approached Sverdlovsk, some four hours into the mission, a salvo of 14 SA-2s was launched, according to Oleg Penkovskiy, to give a shotgun effect which seems to have had the desired results for the U-2B dropped out of control and the wings tore away as they became overstressed. The unfortunate pilot managed to extricate himself from the falling wreckage and parachuted down to become the centre of a major international incident.

Was it structural failure?

Penkovskiy also claimed that the shock waves caused by the multiple explosions had caused a structural failure in Powers' aircraft. This conclusion was reached by Soviet investigators who found no evidence of physical damage caused by the SA-2s and is, to say the least, a bit odd. The SA-2 is a big missile, with a 388lb (176kg) warhead, comprising a 287lb (130kg) high explosive charge with an internally grooved casing. This gives a lethal radius of around 200ft (61m), and, excepting direct hits, one would expect lethal damage to be inflicted by fragments.

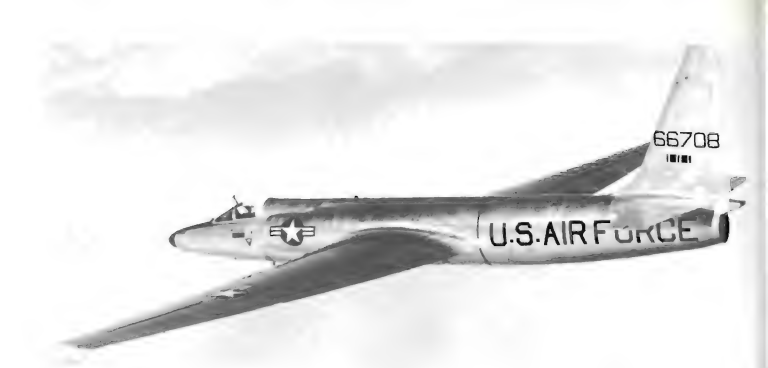
If the explosion(s) occurred too far away for *any* fragments to strike the aircraft, then one would hardly expect the blast to do the job, especially in the thin air at 70,000ft (21,335m) where the effect would be reduced considerably. But, something obviously knocked the U-2 down.

This particular machine is known to have had a history of problems which included engine compressor stalls and it seems feasible that a weak blast might have deflected the tail surfaces at the same time as it caused a compressor stall. At "coffin corner", this could have overstressed the tail section and caused the initial loss of control. If so, Powers was terribly unlucky but we have no way of knowing whether Penkovskiy's version was the true tale.

The loss of Powers' U-2 and the ensuing international furore caused all overflights to cease, with the consequence that all U-2 detachments, including WRSP-3 in Atsugi, were withdrawn to the United States. From this point on, the USAF started to take over many missions that had formerly been the sole province of the CIA.

Activity in Cuba

For a while, the U-2 outfits kept a low profile. Then, in 1962, the pot started coming to the boil again, when a CIA aircraft flying from McCoy AFB, Florida, obtained pictures of a Soviet military build-up in



Above: **Resplendent in natural metal overall finish, relieved only by national insignia and a distinguished unit citation ribbon, U-2 66708 was serving with the 4080th SRW when this photograph was taken during the late 1950s or early 1960s.**

Cuba. The USAF added their weight to the reconnaissance effort from 9 October, and it was one of their aircraft, flown by Major Steve Heyser, that brought back evidence that Soviet medium-range ballistic missiles were indeed to be installed.

This caused an international crisis of the first order and led directly to the United States blockade of Cuba to prevent the missiles from arriving. Meanwhile, surveillance was stepped up, no less than 82 missions being flown by USAF U-2s between 22 October and 6 December. Inevitably, there was a price to be paid; Major Rudolph Anderson was shot down by an SA-2 on 27 October while some other aircraft were victims of operational accidents. Finally, the missiles were withdrawn and the crisis eased, although monitoring continued for some time.

Operations over China

While this was going on, the Taiwanese were observing nuclear tests on the mainland of China, the first detonation taking place at Nanching in September 1962. This activity continued for many years, during which time at least eight U-2s were lost to the Chinese defences. The CIA acted in a liaison role for the Taiwanese connection and were instrumental in making available the larger and more capable U-2R to Taiwan in 1968.

July 1963 saw the 4080th SRW relocated to Davis-Monthan AFB in Arizona with a nominal strength of 20 aircraft, while an international agreement in the following year to ban atmospheric nuclear tests rendered the HASP-configured aircraft redundant. They were re-equipped to carry optical and ELINT systems.

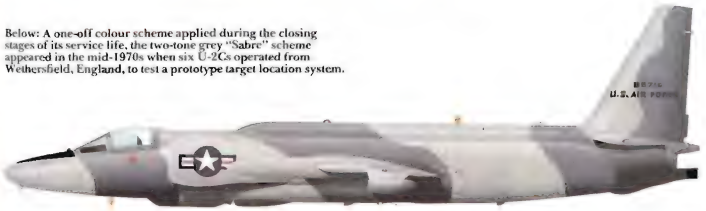
Detachment 20 was formed at Bien Hoa, in South Vietnam, and commenced overflights of the North. At this time, USAF U-2S were finished in natural metal or grey but SAC decided in October 1964 to adopt the all-black scheme favoured by the CIA, the first black USAF U-2 being 56-6680 at Bien Hoa.

The CIA had by this time begun exploring the possibility of operating the U-2 from aircraft carriers. In 1963, two U-2As practiced "bolters" on the *USS Kitty Hawk* (CVA-63) while two modified aircraft known as U-2Cs carried out trials on the *USS Ranger* (CVA-61) during February and March 1964. The specially-fitted spoilers were deployed as the aircraft approached the wires, these killing the lift and, with it, the U-2's tendency to float, the ensuing arrested landings apparently causing no difficulty.

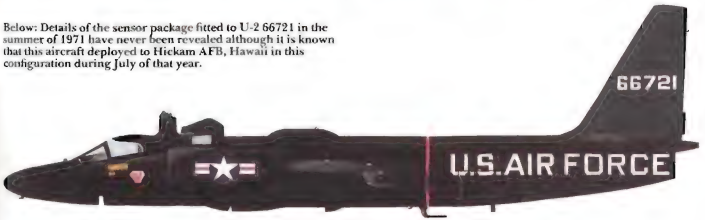
No official comment has ever been made, but it is reasonable to speculate that a curving approach to the deck would be needed to keep the U-2 out of the turbulent wake of the carrier's superstructure. Launching was simple; the low take-off speed coupled

Below: Liberally splashed with high-visibility dayglo, U-2 66701 spent much of its flying career engaged in projects involving sustained high altitude flight while attached to the 6512th Test Squadron at Edwards AFB, California.

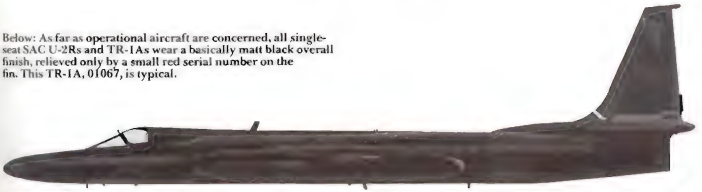
Below: A one-off colour scheme applied during the closing stages of its service life, the two-tone grey "Sabre" scheme appeared in the mid-1970s when six U-2Cs operated from Wethersfield, England, to test a prototype target location system.



Below: Details of the sensor package fitted to U-2 66721 in the summer of 1971 have never been revealed although it is known that this aircraft deployed to Hickam AFB, Hawaii in this configuration during July of that year.



Below: As far as operational aircraft are concerned, all single-seat SAC U-2Rs and TR-1As wear a basically matt black overall finish, relieved only by a small red serial number on the fin. This TR-1A, 01067, is typical.



Right: One of several WU-2As known to have participated in the HASP project, 66712 visited Upper Heyford, England, in connection with that work in 1962 and was last reported in USAF service in 1964. This drawing depicts it in what appears to be U-2A configuration but it was probably modified to U-2B or U-2C standard at some time during its operational career.

Above: The significance of the cat's head motif on the fin of U-2R 10331 in 1982 is not known but such markings have often adorned this otherwise drab type. At the time this design was displayed, this "superpod"-configured aircraft was active with Detachment 2 of the 9th SRW from Osan AB, Korea.

Below: One of the two early production aircraft reconfigured to serve in the pilot training role, U-2CT 66692 wore a basically white scheme in conjunction with SAC's traditional star-spangled sash and a bicentennial shield on the fin which effectively dates it to about 1976. Individual unit markings are now rare.

Below: This view of TR-1A 01067 depicts the aircraft shortly after it was delivered to the 9th SRW at Beale AFB, California. "Superpods" are fitted, and it also features a photographic package in the Q-bay, as evidenced by the clear panel just aft of the cockpit.

Below: The massive wing of the Lockheed U-2R and TR-1 is apparent in this plan view of a "superpod"-configured aircraft. Noteworthy features are the split trailing edge flaps necessitated by fitment of the pods and the fuel dump outlet on the starboard wing.

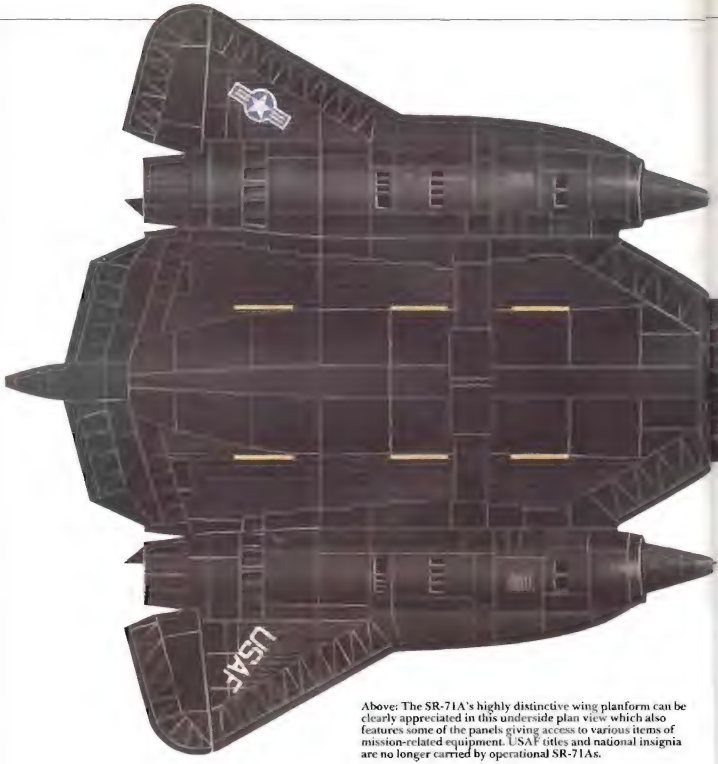
Above: Active between 1966 and 1976, the 350th SRS was responsible for managing SAC's unmanned drone reconnaissance programme and formed part of the 100th SRW. Sister squadron, the 349th SRS, was equipped with U-2s throughout this period.

Above: Established in May 1956 as part of the 4080th SRW, the 4028th SRS received its first U-2 in June 1957 at Laughlin AFB, Texas. Moving to Davis-Monthan AFB, Arizona, in 1963 with the rest of the Wing, it became the 349th SRS in June 1966.

Above: SAC's premier strategic reconnaissance unit has to be the 1st SRS which is responsible for operating the small fleet of Lockheed SR-71A Blackbirds, a task it has managed since June 1966 as part of the 9th SRW at Beale.

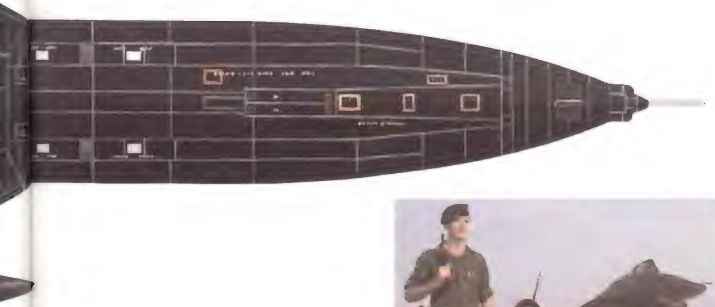
Above left: Engaged in the reconnaissance business from 1966 until 1976, the 100th SRW was responsible for controlling U-2 and unmanned drone operations via two constituent squadrons.

Above right: SAC U-2 operations began in the summer of 1957 and were initially entrusted to the 4080th SRW which was established at Laughlin AFB, Texas.



Above: The SR-71A's highly distinctive wing planform can be clearly appreciated in this underside plan view which also features some of the panels giving access to various items of mission-related equipment. USAF titles and national insignia are no longer carried by operational SR-71As.

Right: Now SAC's crack reconnaissance outfit, the 9th SRW is responsible for managing SR-71A and U-2R/TR-1A operations from its headquarters at Beale AFB, California. At present, the Wing has permanent detachments at six other locations, encompassing Europe, the Middle East and the Far East.



Right: Complete with M16 rifle slung over his shoulder and with a holstered revolver on his hip, a USAF guard stands watch over a Lockheed SR–71A Blackbird at Beale AFB. Such overt signs of security are rare since SR-71As generally operate from fairly secure areas anyway.

Below: Displaying the 9th SRW's shield on its vertical tail surfaces, SR-71A 17979 also features the "high-visibility" scheme that prevailed until about three years ago. Now, like its erstwhile colleague, the U-2, the Blackbird carries only a small red serial number on the fin.

Above: As noted elsewhere, the contemporary Blackbird scheme is singularly drab as well as particularly appropriate; the national insignia and USAF titles have now been deleted. This leaves only the five-digit serial number as a means of identification as seen on 17972 portrayed here.

Below: Another mission complete, the pilot and reconnaissance systems officer of an SR-71A leave their aircraft to the tender mercies of the technicians and head for debriefing. Missions staged from Mildenhall vary in length but seldom exceed four hours.

Below: Portrayed in the markings it wore when it logged its 1,000th training sortie, SR-71B 17956 is the only surviving example of the two aircraft built for this purpose.

Above: Confirmation of Soviet military assistance to Nicaragua is provided by this view of Sandino airport. Apparently taken from a U-2, four Mi-24 Hind Ds and one Mi-8 Hip are visible.

with the wind generated over the deck gave the U-2 sufficient lift after a run of about 300ft (91m); catapult assistance was not needed. Details of carrier-based sorties are classified, but it is known that French nuclear tests at Mururoa Atoll, in the Pacific, were monitored by this means. The CIA later went on to conduct carrier suitability trials of the U-2R on the *USS America* (CVA-66) in November 1969, these being flown by a Lockheed test pilot. The operational use of U-2Rs from aircraft carriers is not known.

In the ten years from 1966 to 1976, considerable re-shuffling took place. In 1966, the 4080th SRW and 4028th SRS evolved into the 100th SRW and 349th SRS respectively, while, in 1970, the Bien Hoa detachment moved to U-Tapao in Thailand where it was designated as the 99th SRS. It was finally withdrawn from Thailand in April 1976 and its aircraft were dispersed to OLs around the world.

In 1968, the CIA had taken delivery of the first U-2Rs and commenced operations using Edwards as a main base, but, by 1974, reconnaissance satellites were fulfilling many of the tasks previously the province of the U-2. As a result, later that year, all of the Agency aircraft were transferred to the USAF, CIA activities in this field ceasing entirely in the following year.

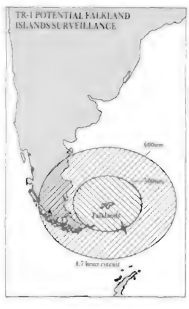
This accession of strength was very welcome to the USAF, whose U-2 inventory had been sadly depleted by attrition. The 100th SRW had detached two U-2s to Akrotiri, Cyprus between August and December 1970; they were back on station in 1973 as a result of the October War in the Middle East and there has been a U-2R presence there almost permanently ever since. Then, in October 1976, the 100th SRW was redesignated as an Air Refuelling Wing at Beale

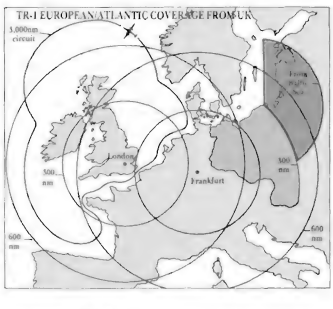
AFB, California, its reconnaissance resources being distributed between Tactical Air Command and SAC. As a consequence, the 99th SRS now became the principal U-2 operating squadron, forming part of the 9th SRW which also resided at Beale.

New stand-off roles were being found for the U-2 and a system designed to located enemy emitters was developed under the code name "Pave Onyx." This was to use three aircraft in precisely known positions with receivers, simple triangulation techniques being employed to establish emitter sites. This system, with its derivative, "Pave Nickel", was first tested in Europe by six U-2Cs in the summer of 1975 while just one year later, U-2Rs of the 99th SRS, configured for ELINT/SIGINT/COMINT tasks, were periodically detached to RAF Mildenhall, huge headquarters of USAFE, where they remained until early in 1983 when the TR-1A began to reach Alconbury.

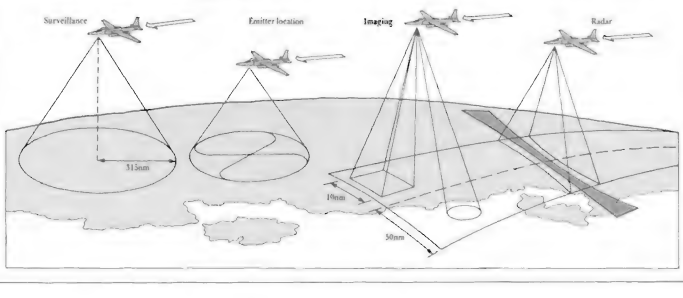
Part of the work undertaken from Mildenhall involved testing the "Pave Onyx/Pave Nickel" system which had evolved into the Precision Emitter Location Strike System (PLSS). This was the forerunner of the system now carried by the TR-1A, the first unit being the 95th RS/17th RW which was formed at RAF Alconbury in 1982. Early in the following year, the TR-1Bs were assigned to the resuscitated 4029th SRTS at Beale AFB.

With equipment proceeding, the U-2/TR-1 family looks well set to prolong its already extensive operational career but who could have guessed back in the fifties that the surviving USAF U-2Cs would not be phased out until 1982 or that two aircraft of this version would still be gainfully employed by NASA in 1986.





Left: Some idea of the TR-1A's potential as a surveillance platform can be gleaned from this diagram of the area around the Falklands. One aircraft in orbit around the islands can monitor a large area of Argentina.
Right: In the European theatre, a few U-2s or TR-1s operating from just two bases could effectively survey all the vast area depicted.
Below: Functions which can be undertaken by the TR-1A include (l to r) basic surveillance, emitter location, imaging and radar scanning. Sensor configurations naturally vary with mission.



7

The Lockheed A-12/YF-12/SR-71

If the U-2 was pushing the contemporary state of the art pretty hard, then the requirement that led to the Blackbird family was out of sight. The U-2 was designed to evade hostile defences by flying too high for them to reach. Every problem has a solution, and, inevitably, defensive measures would be evolved to deal with the U-2, which, when it entered service, was reckoned to have an effective life of about two years.

In the event, this was doubled to four years, a very short time when one considers how long it takes to develop an advanced aircraft. It was therefore obvious that if overflight was to remain a viable method of gathering intelligence, something better would soon be needed.

It was equally obvious that any successor would need to be supersonic in order to avoid the "coffin corner" limitations of the earlier machine. Supersonic speed would render fighter interception more difficult, as the time to scramble and reach the appropriate altitude would be greatly reduced, while surface-to-air-missile accuracy would need to be increased in order to be effective.

More speed for safety

The SA-2 Guideline has, as we have seen, a lethal diameter of around 400ft (122m). A U-2 flying at 450kt (834km/hr) would traverse this distance in 0.52 seconds. At Mach 3, however, the same distance would be covered in less than 0.14 seconds. The missile guidance system would, therefore, have to be nearly four times better to achieve the same kill probability (P_k). By the same token, only a quarter of the time would be available for the missile system to acquire its target, launch, and reach the target's altitude.

Originally, a design powered by liquid hydrogen was proposed, the Skunk Works being awarded an Air Force contract in April 1956, to develop and build two prototypes of the CL-400, which resembled nothing so much as an outsized F-104 Starfighter but with an engine on each wingtip rather than buried in the fuselage. Problems led to cancellation of this project in late 1957 when a more conventional approach was adopted. The requirement remained as a high-speed, high-altitude reconnaissance aircraft and the driving force behind it was, as had occurred with the U-2, the CIA.

After the evaluation of three contending schemes, Lockheed was awarded a development contract for "Project Oxcart", as the requirement was now known, on 29 August 1959 and it is interesting to note that the Lockheed design was less radical than its competitors, the General Dynamics submissions being aimed at Mach 6. On the other hand, the Lockheed A-12—often erroneously referred to as the A-11—was still pushing the state of the art pretty hard, although it offered less technical risk than its rivals. For instance, over nine-tenths of the A-12's structural weight was made up of titanium, a material which, although it conferred most of the advantages of steel for half the weight, was very difficult to work with in those days.

The first A-12, Air Force serial number 60-6924, was delivered to Groom Lake by road in January 1962, just 29 months after contract award. Here, it was assembled and prepared for its first flight, and after a series of taxying trials and one short "hop", this was duly made by Lockheed test pilot Lou Schalk on 26 April.

The A-12 was an odd-looking beast by any standards. It was big for a single-seater, although considering the amount of fuel that it had to carry to achieve the required range, that was not too surprising. Excluding the nose probe, it was 98.75ft (30.10m) long with a wing span of 55.58ft (16.94m). The design had been optimised for a sustained high-altitude cruising speed of Mach 3 and some highly original solutions to the problems of flight in

this regime had emerged. Not least of these problems was heat, hence the extensive use of titanium. Kinetic heating can raise skin temperatures to between 300 and 400 deg and allowance had to be made for a considerable amount of expansion and contraction.

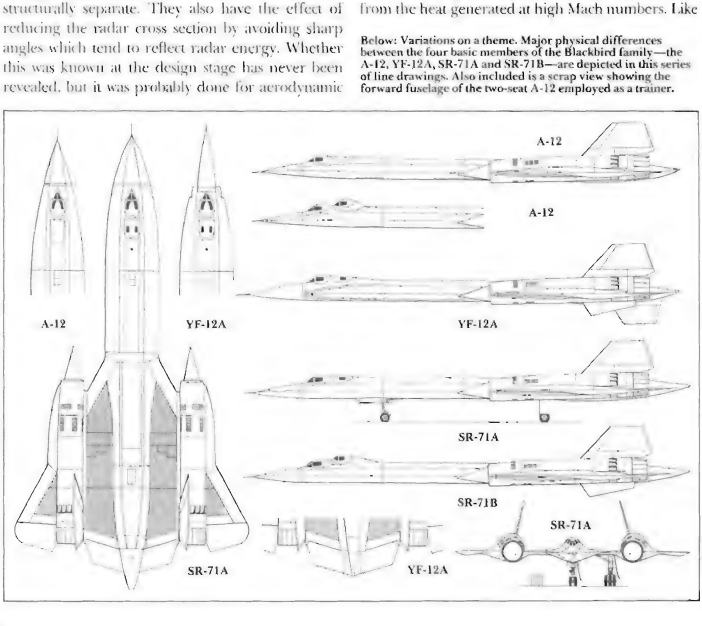
Fuselage detail

While not immediately apparent, the fuselage was of roughly cylindrical cross-section. This was disguised by the blending of the wings into the body, coupled with a blended strake, usually referred to as a chine, extending from the leading edge of the wing to the very nose. The chine adds directional stability and creates lift, helping to reduce trim drag at high speeds. The chine and wing/body blending give the fuselage a flattened appearance, but they are, in fact, structurally separate. They also have the effect of reducing the radar cross section by avoiding sharp angles which tend to reflect radar energy. Whether this was known at the design stage has never been revealed, but it was probably done for aerodynamic reasons, the "stealth" features being entirely fortuitous. The other distinctive feature of the fuselage is a slight upward cant, adopted to reduce trim drag.

The cockpit was closely faired into the fuselage and used a knife-edged V-shaped windshield similar to those of the Convair F-102 and F-106. Whereas both of those fighters suffered from annoying reflections on the inside of the windshield and were forced to adopt a matt black screen mounted vertically and aligned with the "V" to obviate this, no such item seems to have been necessary on the Blackbird series. Presumably it occurred, but the pilot could live with it.

Compared with the U-2, the undercarriage was conventional, the twin nosewheel retracting forwards, with triple-wheeled main gears mounted outboard retracting sideways into fuselage bays which incorporated special insulation to protect the tyres from the heat generated at high Mach numbers. Like

Below: Variations on a theme. Major physical differences between the four basic members of the Blackbird family—the A-12, YF-12A, SR-71A and SR-71B—are depicted in this series of line drawings. Also included is a scrap view showing the forward fuselage of the two-seat A-12 employed as a trainer.



the U-2, the A-12 and its derivatives were not designed for hard manoeuvring, being limited to minus 1g and plus 3.5g.

Also optimised for very high-speed, non-manoeuvring flight, the wings were of delta configuration, with a leading edge sweep of slightly more than 52.5 deg while the trailing edge swept forward at roughly 10 deg. In distinct contrast to the U-2, the aspect ratio was very low at 1.92, while the thickness/chord ratio was an astonishingly thin 2.5 per cent.

Differentially moving elevons with an up travel of 35 deg and down travel of 20 deg, occupy the entire trailing edge. There are no flaps or spoilers on the wing, and this, coupled with the delta configuration, means high take-off and landing speeds, believed to be of the order of 175kt (324km/hr) and 150kt (278km/hr) respectively. This is despite the fact that the wing loading on the A-12, at 75lbs/ft^2 (365kg/m^2) at TOGW, is quite moderate.

Below: The futuristic lines of the Lockheed SR-71A are readily apparent in this head-on view of an early production example. Also worthy of note is the fact that the colour scheme appears to be a mixture of black and natural metal, instead of the overall black that was eventually adopted as standard.

Good handling qualities

High take-off and landing speeds apart, the A-12 and its derivatives apparently handle well, with no nasty tricks, while the angle-of-attack (AOA) on take-off and landing is not excessive for a delta. A feature of the wings, the inboard sections of which serve as integral fuel tanks, is the longitudinal ribbed effect on both top and bottom of the inboard section. This fulfils two functions. First, it provides additional rigidity and second it helps to take up expansion caused by kinetic heating which might otherwise distort the surfaces and cause extra drag. The leading edges are also designed to resist distortion caused by kinetic heating and feature conical camber optimised for flight at high Mach numbers. This gives a very strange appearance from head-on, especially on the outboard wing sections, which also have a chine running from the leading edge to the front of the engine nacelle.

Most unusually, the huge J58 engines are positioned well outboard. In this location, sluggish boundary layer air from the fuselage forebody is

kept well clear of the intakes, while the nacelles provide more keel area for high speed stability. This choice of location also gives more surface nacelle area to accommodate the louvres for the centrebody bleed air, bypass relief louvres and doors, and tertiary air flaps which admit air to cool the afterburner.

Sensors and fuel in fuselage

It also frees the fuselage to carry the vast amount of fuel needed, as well as sensors, while a final consideration may have been that compressor or turbine blade failure would be less likely to inflict lethal damage. At the rear end, the nozzles are of the conventional convergent-divergent (con-di) type, with plain flaps. Perhaps the most striking feature of the engine is at the front, where a huge translating shock cone extends nearly 8ft (2.44m) forward of the intake. The outboard location of the engines is insufficient to clear the shock wave generated by the nose section and the translating shock cone is canted several degrees inwards to counter this, giving the Blackbird a slightly cross-eyed look. The nacelles themselves also appear to be tilted slightly inwards, although it is difficult to be certain, while to achieve the AOA necessary for high altitude flight, they are canted slightly downwards.

Pratt & Whitney's J58 turbo-ramjet

The early part of the A-12 flight test programme was conducted with afterburning Pratt & Whitney J75 engines, in lieu of the definitive J58 which was not then available. The latter is what is described as a turbo-ramjet, with a rated maximum static thrust of 32,500lbs (14,472kg), the combined thrust of both engines giving a power loading at TOGW of just 0.54; rather less than the average fighter of the day. However, power loading is a measure of acceleration and climb capability rather than maximum speed and the rather simple single-spool J58 is optimised for the top right-hand corner of the flight envelope.

A simple analogy is a juggernaut on a motorway. This may take a while to reach high speed, but once there, it can sustain it. Similarly, while the Blackbird family may not have the most sparkling acceleration around, it keeps winding up when others are either melting or running out of fuel. In fact, the shock cones do not start translating backwards until a speed of Mach 1.6 is reached.

Below: Wearing the now familiar black overall finish, relieved only by national insignia, USAF titles, serial and "buzz" numbers, the third YF-12A, 06936, reveals the Blackbird's characteristic wing planform to advantage. Note also the cut-back nose chine which was peculiar to this version.

Above: One of the first pictures released portrayed YF-12A 06934 in the black and silver finish that was initially applied. The YF-12A's folding ventral fin is also clearly visible.

Twin fins are mounted on top of the engine nacelles. These are unusual in that they have a fixed stub portion, while the entire top section is movable. An all-moving fin is more effective in supersonic flight than a fixed fin and rudder, while at high Mach numbers a low aspect ratio fin, such as that on the Blackbird series, is to be preferred. The fins are canted inwards at about 15 deg, which acts to reduce the rolling moment generated by sideslip. There is a spin-off effect to this in that a 90 deg radar reflecting angle with the nacelle is avoided, and the radar signature is thus reduced. One danger with such widely spaced engines arises from asymmetric thrust, which would occur in the event of engine failure or loss of thrust on one side. If this happens, a large amount of rudder is fed in automatically, to counter the resulting yaw which could if unchecked take the aircraft beyond structural limits with disastrous results.

The U-2 series was limited in range more by pilot endurance than by fuel. This is not the case with the Blackbird, which is a thirsty beast and which has been configured from the outset for in-flight refuelling, a receptable being located in the centre fuselage section behind the cockpit. The high landing speed also makes a braking parachute necessary and this is housed in a dorsal compartment set towards the rear.

Below: "Mother Goose and chick". One of the two A-12s that served as a mother ship for the GTD-21 drone is seen in flight with a drone attached. Bottom: As far as is known, the A-12/GTD-21 pairing did not progress beyond the test stage although the drone was used operationally from the B-52H.

Godscan ltd

8

Production and Service

A total of 15 A-12s was built, with USAF serials 60-6924 to 60-6933, and 60-6937 to 60-6941. Few A-12 photographs have been released and those that have depict the aircraft in Air Force markings. In fact, programme secrecy was preserved until February 1964, when its existence was revealed by President Johnson, who referred to it as the A-11, thus starting that particular canard.

As with the U-2, it was found advantageous to have a two-seater training variant, aircraft number 60-6927 being produced with a second cockpit raised above the line of the first and occupying space normally taken by the Q-bay. This aircraft was fitted with J75 engines and had no operational capability, its top speed being just Mach 1.2.

Although the A-12 was plagued with technical problems for the first two years of its flying career, CIA pilot training started in about mid-1963. Details of the missions flown are virtually non-existent but it is known that the type operated from Groom Lake and from a CIA enclave at Kadena AB, Okinawa. In all, six of the 15 A-12s built fell victim to accidents but only one could truly be described as an operational loss, this disappearing soon after departure from Kadena in June 1968 and bringing that particular operation to a sudden halt. Nonetheless, the A-12 had the best performance of any member of the Blackbird family, reportedly being capable of attaining Mach 3.6—about 2,065kts/3,827km/hr and 95,000ft (28,995m).

The final two A-12s were modified to carry the GTD-21B drone, a second crewman being carried in the converted Q-bay, while the drone was mounted on a pylon above the rear fuselage. In this configura-

Below: The first of two purpose-built SR-71B two-seat trainers, and, incidentially, the only surviving example, 17956 has logged well over 1,000 sorties since it entered service with the 9th SRW at Beale AFB, California in the mid-1960s.

tion, the A-12 became the M-12, although it was probably better known by those associated with the programme as "Mother Goose".

The GTD-21B was a ramjet-powered, Mach 4 capable, reconnaissance platform for high-risk overflight missions. Launched from a high-speed, high-altitude platform such as the M-12, it would fly a pre-programmed course, gathering data and storing this in a special package which would be ejected at a predetermined point for retrieval by a suitably modified C-130. The drone itself was expendable but the GTD-21/M-12 combination was abandoned following the loss of 60-6941 in July 1966 during a test launch. The GTD-21 may, however, have been used operationally in concert with the B-52H as a "mother-ship".

A Blackbird interceptor

In September 1959, the North American F-108 Rapier Mach 3 capable fighter had been cancelled, mainly due to lack of funds. However, the requirement remained and it was decided to explore the possibility of using an A-12 variant as an interceptor. This duly emerged as the YF-12A, three examples of which were built. Given the serial numbers 60-6934 to 60-6936, the first of these made its maiden flight from Groom Lake on 7 August 1963 and it differed from the A-12 quite considerably.

For a start, at 101.67ft (30.99m) long, the fuselage had been slightly extended whilst it was also a dedicated two-seater, with a weapons system officer ensconced in a flush-faired cockpit behind the pilot. The nose had been redesigned to house the Hughes AN/ASG-18 radar, originally developed for the North American F-108.

The ASG-18 was the first coherent pulse Doppler radar to be designed for fighter use and incorporated the travelling wave tube instead of the magnetron. This, allied to recent advances in digital computer technology, bestowed look-down capability, a feature absent from earlier radars. The radar range was around 100 naut. miles (161km), and the weapon adopted, also developed for the F-108, was the Hughes GAR-9 (later AIM-47A) which was capable of Mach 6 and which possessed a range capability matching that of the radar. Three AIM-47As were carried in internal weapons bays.

The nose chines were cut back clear of the radome and infra-red sensors were installed in the chine leading edge on both sides. The nose modifications resulted in reduced stability which was compensated

Below: Production of the SR-71A for Strategic Air Command kicked off with 17950, seen here in flight somewhere over the western USA. SAC has always been coy about figures but this aircraft is believed to be one of several which have crashed.

Above: 06932 probably donned USAF insignia for this rare photograph of an A-12 since it is understood that CIA aircraft wore no markings save for small red serial numbers on the fin.

programme at Groom Lake and Edwards, the YF-12s were leased to NASA, where they were joined by a single YF-12C. This was basically the second production SR-71, serial 64-17951, which adopted the bogus identity "06937" that was, of course, retained by the eleventh A-12. As the YF-12C, it carried no military equipment and should, more correctly, be considered as an experimental SR-71. The F-12B designation was never issued but would probably have been used by the production article had the fighter version been ordered for service with the Air Defense Command. The last surviving YF-12A, serial number 60-6935, was retired in November 1979 and can now be seen in the Air Force Museum at Wright-Patterson AFB, near Dayton, Ohio.

An A-12 development which never reached fruition was a proposed bomber variant known as the R-12. Little information has come to light concerning this model although the weapons would have been carried in underfuselage bays similar to those of the YF-12A.

The final development of the Blackbird family was the one with which we are most familiar, namely the SR-71 although even here, the designation has become fudged for it should have been the RS-71, following on from the proposed RS-70 reconnaissance variant of the tri-sonic Valkyrie bomber. Unfortunately, President Johnson referred to it as the SR-71 in July 1964 and one presumably does not argue with Johnsons, be they either President or Kelly.

Blackbirds for SAC

A dedicated two-seater from the outset, the SR-71 was ordered in December 1962, with the redesign process commencing two months later. The aircraft which resulted was 5.08ft (1.55m) longer, most of the extra length being accounted for by an extended tailcone, and three inches (7.5cm) higher at the fin tip. It was considerably heavier and carried a greater payload and much more fuel. The chines extended to the tip of the nose and were of slightly revised outline. The ventral fins carried by the YF-12 were not present.

The first SR-71A, serial number 64-17950, made its maiden flight on 22 December 1964 and deliveries to the USAF got under way on 7 January 1966, when SR-71B 64-17957 was handed over to the 4200th SRW at Beale AFB. This unit evolved into the 9th SRW in the following June, the SR-71s then being operated by the 1st SRS. A total of 32 SR-71s was delivered, including the YF-12C mentioned earlier.

Serial numbers ran continuously from 64-17950 to 64-17981, aircraft 64-17956 and 64-17957 being produced as trainers with the designation SR-71B. This model differed from the SR-71A in having a raised rear cockpit, which in turn destabilised the aircraft longitudinally, necessitating the adoption of fixed ventral fins beneath the engine nacelles. The final aircraft, serial number 64-17981, was the only SR-71C to appear and was also a trainer with the elevated rear cockpit and ventral fins. Known colloquially as "the Bastard", it was not a new-build aircraft, being produced by marrying the rear end of crash-damaged YF-12A 60-6934 to the front end of an engineering mock-up. As such it was never very satisfactory and has spent most of its life as a "hangar queen", appearing sporadically when the surviving SR-71B (64-17956) is in for overhaul.

Like the A-12, operational details are scanty. The 1st SRS is the only operating unit, although detachments have been and still are maintained overseas, most notably at Kadena (Det. 1) and RAF Mildenhall (Det. 4). Overflights of China, the Middle East, Afghanistan and Iran are believed to have been made and none have been lost to hostile action, although the attrition rate is comparable to that of the U-2.

The battery of cameras and sensors carried is formidable. The USAF Fact Sheet issued by SAC—an organisation not noted for overstatement—credits the SR-71 with the ability to scan more than 100,000 square miles (259,000km^2) of the earth's surface in one hour from above 80,000ft (24,383m).

Possibly only a dozen SR-71s are still operational, but they look like being around for a considerable time yet, unless the persistent rumours that Lockheed's stealth aircraft, the F-19, has visited Europe are true, in which case the Blackbird may well have a successor to hand.

Like the YF-12A, the SR-71 has also done its share of record breaking, its exploits being examined in more detail in the accompanying table.

SR-71 RECORDS

26 April 1971.	Distance 15,000 miles (24,140km) in 10 5 hours Crew: Majors Thomas B. Estes and Dewain C. Vick.
27 July 1976.	Sustained altitude . . . 85,069ft (25,927.765m) Crew: Captain Robert C. Helt and Major Larry A. Elliot.
27 July 1976.	Absolute speed . . . 2,193.17mph (3,529.37km/hr) Crew: Captain Eldon W. Joersz and Major George T. Morgan.
27 July 1976.	1,000km closed circuit. . . . 2,092.294mph (3,367.13km/hr) Crew: Majors Adolphus Bledsoe and John T. Fuller.
1 September 1976.	New York to London. . . . 1hr 55min 42sec. Crew: Majors James V. Sullivan and Noel F. Widdifield.
13 September 1976.	London to Los Angeles . . . 3hr 47min 39sec Crew: Captain Harold B. Adams and Major William C. Machorek.

Below: Taken in the spring of 1967, little more than a year after the SR-71A entered service with SAC, 17967 of 9th SRW gets airborne from Beale AFB, California, at the start of a training mission. Despite its short existence, the 9th had probably already achieved great things since this aircraft displays the distinguished unit citation ribbon on the fin.

Generally, the A-12/YF-12/SR-71 series have worn a special heat-radiating black livery, from which the name Blackbird derived. This paint also has radar absorbent properties and at high temperatures turns indigo blue.

This has, however, not always been the case and it is possible that the prototype A-12 first flew in a natural metal finish. As most of the skin is titanium, this does not give the same effect as polished aluminium, but is dull with a yellowish tinge.

Variations in overall finish

Later on, examples of the A-12 and YF-12 were seen with black on the nose, the chines, the leading and trailing edges of the wings, and with a mask around the cockpit, the rest of the structure being bare metal. These carried U.S. AIR FORCE titles in black ahead of the star-and-bar in mid-fuselage, black serials on the rudders and no wing markings. A-12 60-6932 also appeared in all-over black but with the rudders in natural metal, the U.S. AIR FORCE legend being in white.

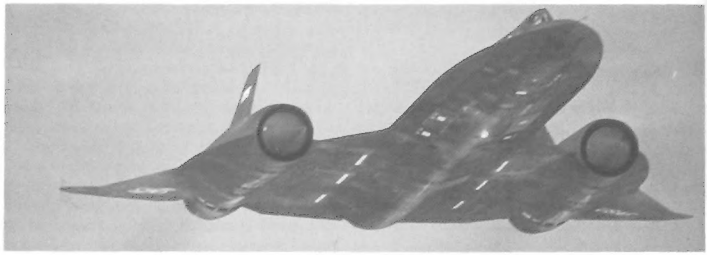
Some aircraft also appeared with the last three digits of the serial number on both engine nacelles in white or black depending on the background colour. For instance, YF-12A 60-6934 carried 934 in this position in black on bare metal, prefixed by FX (fighter experimental). Displaying the "last three" on the nacelles was particularly common with aircraft bailed to NASA, which also carried the NASA logo on a yellow stripe on the rudders.

The first SR-71A was interesting in that it carried a reversed half-paint scheme in black with the chines and leading edges left unpainted. This was perhaps an experiment to determine the exact effect of the radar absorbent paint. Of the all-black aircraft, the modern trend seems to have reverted to CIA practice of the mid-1960s, these carrying just an abbreviated five-digit serial number on the fin in small dull red figures. Earlier, full USAF markings were carried in the main.

One-off markings

Various individual touches have appeared over the years, then vanished again. When assigned to Detachment One at Kadena, SR-71A 64-17971 carried a white "habu", which is a type of pit viper found in Okinawa, pierced with the red number 1 on the rudder, smaller white habus being displayed as mission markings behind the rear cockpit. The legend "ICHI BAN" also appeared in red under the habu on the rudder.

Below: An SR-71A closes for contact with a KC-10A Extender. In-flight refuelling of the Blackbird is normally undertaken by KC-135Q Stratotankers assigned to the 9th SRW, the 376th Strategic Wing and the 380th Bomb Wing, this model being specially adapted to carry the JP7 fuel that is used by the SR-71A.



In Europe, 64-17964 appeared briefly with the legend "Bododian Express" following an unscheduled diversion during a mission from Mildenhall while several aircraft have carried the 9th SRW crest on the fins. Other markings include the Lockheed Skunk Works logo and the ubiquitous Playboy Bunny, which appeared in white on 64-17978 along with the inscription "Rapid Rabbit".

Above: The menacing appearance of the Blackbird is well depicted in this underside view of the SR-71A on take-off. Mission-related sensor equipment is located in the forward fuselage ahead of the wing.

Below: The small amount of glazed area available to the pilot and reconnaissance systems officer can be gauged from this close-up of the cockpit area on an SR-71A.

Bottom: Two mechanics check that panels on one of the SR-71A's massive J58 engine pods are secure before giving the go-ahead to taxi at the start of another mission.

BLACKBIRD DIMENSIONS

	A-12	YF-12	SR-71
Length ft (excl. probe)	98.75	101.67	103.83
m	30.10	30.99	31.65
Span ft	55.58	55.58	55.58
m	16.94	16.94	16.94
Height ft	18.25	18.25	18.50
m	5.56	5.56	5.64
Wing Area ft^2	1,605.00	1,605.00	1,605.00
m^2	149.15	149.15	149.15
Aspect Ratio	1.92	1.92	1.92
Thickness/chord ratio	2½%	2½%	2½%

BLACKBIRD WEIGHTS (Estimated)

Empty lbs	60,000	60,730	67,500
kg	27,216	27,547	30,618
Take-off Gross lbs	120,000	127,000	172,000
kg	54,432	57,607	78,019
Max fuel load lbs	46,000	46,000	84,180
kg	20,866	20,866	38,184
Wing Loading (TOGW)			
lbs/ft^2	74.77	79.13	107.17
kg/m^2	365.10	386.39	523.31
Power Loading (TOGW)	0.54	0.51	0.38

Engines. . .All versions. Two Pratt & Whitney J58 turbo-ramjets, each rated at 32,500lbs (14,742kg) static thrust at sea level.

BLACKBIRD PERFORMANCE (Estimated).

	A-12	YF-12	SR-71
Maximum Speed Mach	3.6	3.5	3.5
Sustained Ceiling ft	95,000	85,000	85,000
m	28,955	25,907	25,907
Range at Mach 3 miles	2,500	2,500	3,250
km	4,023	4,023	4,023
Range with IFR miles	n/a	n/a	15,000+
km	n/a	n/a	24,140+
Endurance at Mach 3	1 hour 30 minutes.		

8

Other American Spyplanes

So far we have examined the two most glamorous types in the electronic and photographic reconnaissance field, but there are many more, quietly carrying out work of the utmost value, flying long and outwardly boring patrols in their endless search for information.

The most important numerically is the Boeing RC-135 family. A large four-jet aircraft, it cruises at around 480kt (890km/hr), has a ceiling of about 40,000ft (12,200m) and an unrefuelled range of 3,500 naut. miles (6,500km). It is large enough to carry a comprehensive ELINT suite and often SLAR also. Crew numbers vary but can reach a maximum of 21, including pilots, navigators, a system director, systems operators, a maintenance technician and a relief crew. Sub-types currently in service are the RC-135S, 'U', 'V', 'W and 'X, all of which feature various aerial and antennae arrays. The mission priorities are believed to be monitoring the Soviet air defence system, their missile and space programme, and the surveillance of potential trouble spots.

There have been many surveillance variants of the ubiquitous C-130 Hercules down the years, and one of these was shot down near Yerevan in Armenia in September 1958, with the loss of 17 lives. The only variant still in service with United States forces is the EC-130E Coronet Solo II, eight of which are operated by the Pennsylvania Air National Guard. Obviously equipped for ELINT, SIGINT and COMINT, to judge from the array of aerials and antennae carried, its exact function is unclear. Yet another product of the Lockheed Company, although not the Skunk Works this time, the Hercules is powered by four Allison T56 turboprops, cruises at around 300kt (556km/hr); has a ceiling of 33,000ft (10,058m) and a range of around 3,000 naut. miles (5,600km).

The United States Navy operates two dedicated ELINT units, tasked with surveillance in support of naval operations and specific reconnaissance along the borders of hostile territory. Two basic types of aircraft are used by both units, namely the Lockheed

Below: Despite its great age, the Douglas EA-3B Skywarrior still has an important part to play in the acquisition of electronic intelligence. This particular aircraft is from VQ-2 at Rota.

Above: Representing SAC's large fleet of specially modified Stratotankers, RC-135U 14849 of the 55th SRW features an interesting array of bumps and bulges around the hose tail.

EP-3 Orion, derived from the maritime patrol platform, and the McDonnell Douglas EA-3B Skywarrior, which owes its origins to a carrier-based jet bomber and which, despite its age, is retained to give the fleet a ship-borne ELINT capability. The Orion is also powered by four Allison T56 turboprops, and has long range but unexciting performance. Packed with electronic gear, it is operated by a crew of 15. By contrast, the Skywarrior has twin jet engines, a good, albeit subsonic, performance, relatively short range and even less endurance with a crew of six.

AMERICAN STRATEGIC RECONNAISSANCE UNITS AS AT 1 APRIL 1986

UNITED STATES AIR FORCE

Wing/Group	Element	Base	Type(s)
6th SW	HQ	Eielson, Ak	–
	Det.1	Shemya, Ak	RC-135S/X
	24th SRS	Eielson, Ak	RC-135S/X
9th SRW	HQ	Beale, Ca	–
	Det.1	Kadena, Okinawa	SR-71A
	Det.2	Osan, Korea	U-2R
	Det.3	Akrotiri, Cyprus	U-2R
	Det.4	Mildenhall, UK	SR-71A
	Det.5	Patrick, Fl	U-2R
	Det.6	Norton, Ca	?
	1st SRS	Beale, Ca	SR-71A/B
	99th SRS	Beale, Ca	U-2R, TR-1A
	4029th SRTS	Beale, Ca	TR-1A/B
17th RW	HQ	Alconbury, UK	–
	Det.1	Wethersfield, UK	TR-1A
	95th RS	Alconbury, UK	TR-1A
55th SRW	HQ	Offutt, Nb	RC-135U/V/W
	38th SRS	Offutt, Nb	–
	343rd SRS	Offutt, Nb	–

Note: RC-135 aircraft are assigned directly to parent Wing, with aircrew reporting to the 38th SRS and electronics specialists to the 343rd SRS. Aircraft of the 55th SRW frequently deploy overseas, most notably to bases at Kadena, Okinawa; Mildenhall, England and Athens (Ellenikon Airport), Greece.

193rd ECG	193rd ECS	Harrisburg, Pa	EC-130E

UNITED STATES NAVY

Sqn Number	Base	Aircraft Types
VQ-1	Agana, Guam	EP-3B/E Orion & EA-3B Skywarrior
VQ-1 Det.	Iwakuni, Japan	EP-3B/E Orion & EA-3B Skywarrior
VQ-2	Rota, Spain	EP-3E Orion & EA-3B Skywarrior

Det = Detachment; ECG = Electronic Combat Group; ECS = Electronic Combat Squadron; HQ = Headquarters; RS = Reconnaissance Squadron; RW = Reconnaissance Wing; SRS = Strategic Reconnaissance Squadron; SRTS = Strategic Reconnaissance Training Squadron; SRW = Strategic Reconnaissance Wing; SW = Strategic Wing.

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